The use of clinical photographs to determine clinician's perception of the need for orthognathic surgery in patients of different racial backgrounds presenting with class 3 skeletal discrepancy

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Abstract

Aim: To investigate the impact of patients' race on clinician's perception of the need for orthognathic surgery in patients with class 3 profiles.

Design: Prospective cross-sectional questionnaire.

Method: A questionnaire was distributed to consultant and specialist orthodontists and oral and maxillofacial surgeons in the United Kingdom and Hong Kong. It contained average composite profile images of adult male and female patients from two different racial backgrounds (Caucasian and Chinese) which had been manipulated to produce increasingly severe class 3 skeletal discrepancies in 2mm increments from baseline (0mm) in both the mandible; (+2mm, +4mm, +6mm), and maxilla; (-2mm, -4mm, -6mm). Respondents were asked whether they felt that 'a patient presenting with this skeletal pattern would benefit from orthognathic surgery' and 'how do you rate the level of attractiveness of the profile?' on a 7-point Likert scale. Multi-level logistic regression and multi-level linear regression were used to investigate factors influencing decision to recommend surgery and perception of attractiveness.

Results: The response rate was 62% (N=306). Significantly more clinicians felt that the manipulated class 3 profiles would benefit from surgery compared with baseline ($p=<0.006$, $p<0.001$). Oral and maxillofacial surgeons were 3.94 times more likely to recommend surgery than orthodontists ($p=<0.001$). The image's race and gender, clinician's years since becoming a specialist, specialty and the number of orthognathic patients treated per year were statistically significant factors for predicting perceived benefit from surgery ($p<0.001$). Attractiveness ratings for all manipulated class 3 profiles were statistically significantly different to baseline ($p<0.001$). Attractiveness ratings reduced with increasing severity of class

3 manipulation with -6mm maxilla being rated least attractive (p=<0.001). Maxillary manipulations were on average rated as less attractive than the mandibular manipulation with the same degree of discrepancy. Ethnicity was a statistically significant factor associated with attractiveness rating with Caucasian profiles rated more attractive than Chinese profiles for the same degree of manipulation (p=<0.001).

Conclusion: Oral and maxillofacial surgeons are more likely to perceive benefit from surgery in patients with class 3 skeletal profiles than orthodontists. Ethnicity significantly impacts decision making with Chinese profiles more likely to be perceived as having benefit from surgery than Caucasian profiles, and Caucasian profiles rated as more attractive than Chinese, for the same degree of discrepancy. Mild class 3 skeletal profiles are rated as significantly more attractive than baseline with attractiveness decreasing with increasing severity of the class 3 profile.

Keywords: Orthognathic surgery, class 3 profile, Chinese, Caucasian, facial attractiveness, need for surgery

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1. Introduction

As a society we place a lot of importance on facial attractiveness and tend to regard those with attractive features as more competent, successful and likeable.[1-4,5] Samsonyanová and Broukal (2014) found that improving facial attractiveness was one of the main motivators for both patients and parents in seeking orthodontic treatment.[6] Dental appearance forms a key component of an individual's overall facial attractiveness and the presence of a dental malocclusion has been shown by several researchers to be associated with negative attitudes towards the individual.[5] Due to the perceived negative effects of dental malocclusion upon appearance the demand for orthodontic treatment is high.

Orthodontic treatment aims to correct malocclusion by improving the alignment of the teeth through the use of fixed and removable appliances or growth modification. However, there are limitations as to what can be achieved with appliances alone as teeth can only be moved within the boundaries of the supporting dentoalveolar bone. Moving the teeth beyond this physiological barrier is not recommended as it is highly unstable, causing orthodontic relapse, gingival recession and poor aesthetics.

In patients suffering from significant skeletal discrepancies which are beyond the scope of orthodontics alone; either due to their severity or lack of future growth potential, or those with concerns about their facial appearance, orthognathic surgery may be required to correct the malocclusion.[7] Orthognathic surgery involves surgically repositioning the maxilla and/or mandible into a more harmonious position to improve both occlusion and facial appearance. It is undertaken in a multi-disciplinary setting with the input of both an orthodontist and oral and maxillofacial surgeon. In recent years orthognathic treatment has become more widely available and socially acceptable and therefore its demand has greatly increased.

A malocclusion which often presents with an unfavourable growth pattern leading to facial and skeletal discrepancy is the class 3 malocclusion. The prevalence of this type of malocclusion is 3.5% in Caucasian populations, but increases to 20% in Chinese and Asian populations.[8,9] Although the least prevalent malocclusion, patients with class 3 malocclusion comprise a disproportionately large number of orthodontic patients. Due to the difficulty in correcting this type of malocclusion orthodontically, and the associated poor facial aesthetics, this malocclusion is often treated when the patient is an adult using a combined orthodontic orthognathic surgical approach.

In an ideal world, all clinicians involved in the care of an individual with a skeletal discrepancy would have similar opinions as to whether they feel surgery would be of benefit. Their assessment of the individuals' facial aesthetics would also be important as this can be an influential factor in the decision making process. Agreed norms for facial proportions such as cephalometric analyses, anthropometric measurement and artistic views can be used in treatment planning such cases. However, subjective clinical judgement often remains the most important clinical factor.[10,11, 12] It is unclear as to whether orthodontists and oral and maxillofacial surgeons have similar opinions as to what degree of class 3 profiles would benefit from surgery. As patients with Chinese ethnicity would be more likely to have a class 3 occlusion, is a class 3 profile more acceptable or attractive, for an individual of Chinese ethnicity, compared with a Caucasian individual with the same degree of discrepancy?

2. Literature Review

2.1 Occlusion and Malocclusion

A malocclusion is described as being present when there is a discrepancy in the alignment of the teeth, or an incorrect relationship between the teeth in the opposing dental arches when they are in maximum contact.[13] There are multiple different classification systems used in orthodontics to describe the features of a malocclusion. These can be broadly divided into those which describe the incisor and molar relationships, the skeletal pattern and the soft tissue profile.

2.1.1 Dental Relationships

Angle was the first to classify malocclusions into four different categories based upon the relationship of the maxillary and mandibular first molars with one another; normal occlusion, class I malocclusion, class II malocclusion and class III malocclusion.[14] He defined normal occlusion as being present when the buccal cusp of the upper first molar occludes in the sulcus between the mesial and distal buccal cusps of the lower first molar. In a class I malocclusion the molar relationship is the same as normal occlusion, however there are other irregularities of the dentition. In class II the lower teeth occlude distal to normal, and in class III the lower teeth occlude mesial to normal.[14] The molar classification has been subsequently modified by Andrews, however still conforms to the same broad principles as outlined by Angle.

In addition to the molar classification popularised by Angle, the dental relationships can be further described by assessment of the relative position and relationship of the upper and lower incisors to each other when in occlusion. The British Standards Institute (1983) have defined the four incisor classifications; class I, class II division 1, class II division 2 and class III.[15] When a malocclusion is described, it is generally the incisor classification which is used rather than the molar classification.

2.1.2 Skeletal Relationships

The skeletal pattern is also categorised into three classifications. A class I skeletal pattern is defined as when the mandible lies 2-3mm posterior to the maxilla, and is generally considered ideal.[16] A class II pattern is when the mandible is more posterior to the maxilla than class I and class 3 is when the mandible lies more anterior to the maxilla than class I, (Figure 1).[16] The positions of the maxilla and mandible are relative rather than absolute. A class II skeletal pattern may be due to either maxillary prognathism and/or mandibular retrusion, producing a convex facial profile. Conversely, a class 3 skeletal pattern may be due to maxillary retrusion and/or mandibular prognathism and produces a concave facial profile.

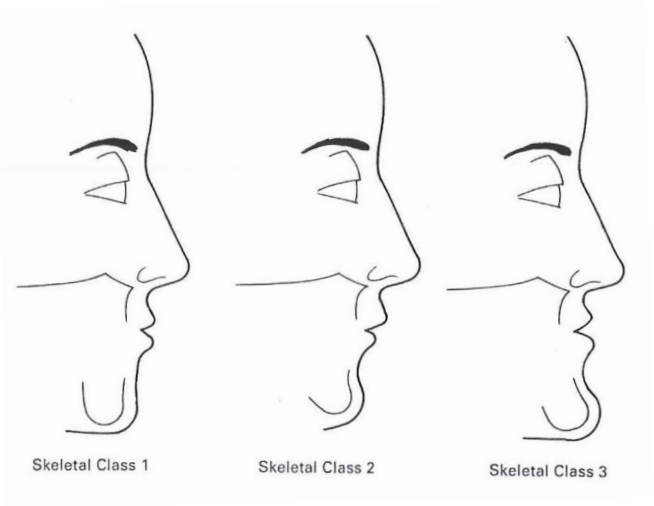


Figure 1: Diagrammatic representation of skeletal classification, (Houston, 1993)

The anteroposterior skeletal pattern is assessed clinically with the patient sitting and the head in the natural head position with the Frankfort plane horizontal to the floor. Assessment of skeletal pattern is generally subjective, however can be supported by angular and linear measurements taken from a lateral cephalometric radiograph.[16] The Eastman cephalometric analysis defines a class 3 skeletal pattern as on in which the ANB angle is less than 2°.

These classifications describe anteroposterior relationships and do not take into account the vertical or transverse anomalies which may contribute to the features of the malocclusion.

2.2 Orthodontic treatment

Orthodontic treatment aims to improve the relationship of the teeth and jaws to one another to improve both aesthetics and function, removing pathology if this exists. The aims of orthodontic treatment are generally to treat each patients' malocclusion to achieve an 'ideal occlusion'.

2.2.1 Aims of orthodontic treatment

Andrews described the features of an ideal static occlusion after studying the study models of 120 non-orthodontic patients with 'normal occlusions'.[17] He determined that in order to have an ideal occlusion six features were necessary to be present which are usually referred to as Andrew's 6 Keys, (Table 1). The aim of orthodontic treatment is usually to finish with the occlusion conforming to these ideals where possible. However, an ideal occlusion is unlikely to be achieved if there is an underlying skeletal discrepancy.

Andrews 6 Keys
Correct molar relationship
Correct crown angulation
Correct crown inclination
Absence of rotations
Tight contact points
Flat curve of Spee

Table 1: Andrews' 6 Keys of Occlusion[17]

2.2.2 Types of orthodontic treatment

There are three main orthodontic treatment approaches for patients with malocclusion; growth modification, orthodontic camouflage or a combination of orthodontics and orthognathic surgery.

In younger patients, who have the potential for future growth, presenting with a skeletal discrepancy, growth modification may be undertaken. This attempts to encourage improvement in skeletal pattern and dentoalveolar relationship through differential growth.[18] Growth modification in class 3 patients aims to either increase anterior maxillary growth or retard mandibular growth through the use of extra-oral appliances.[19] The ideal time to undertake growth modification in class 3 patients is before 10 years old.[20] However, due to the tendency for late mandibular growth, positive correction is often not maintained after growth modification treatment and a class 3 skeletal pattern re-establishes or persists.[21] For patients with an underlying class 2 skeletal pattern, functional appliances are used during the pubertal growth spurt to maximise dental and skeletal changes. Any late mandibular growth will be favourable in maintaining the correction achieved through growth modification. Growth modification in class 2 patients is much more predictable and successful compared with class 3 patients.[18]

Orthodontic camouflage, using fixed or removable appliances, is generally undertaken for patients with a class I skeletal pattern where the malocclusion is limited to the dentition or patients with mild class 2 or 3 skeletal patterns. With this approach, the appearance of the dentition will be improved, however the skeletal pattern will remain unchanged following treatment. Therefore, orthodontic camouflage is not the treatment of choice for patients with significant skeletal discrepancies or who have concerns about their facial appearance as they are unlikely to be satisfied with the results of treatment.

In patients with significant skeletal discrepancies, or with limited future growth potential, it may not be possible to fully correct their malocclusion with orthodontic camouflage.[7] Such patients are often offered a combined orthodontic and orthognathic surgical approach.

2.2.3 Envelope of discrepancy

There is a limitation as to what can be achieved by orthodontics alone in terms of camouflage and in cases of severe skeletal discrepancies in order to achieve improved facial aesthetics and ideal occlusion a combined orthodontic and surgical approach may be required. Proffit *et al*. (1992)[22] discusses "The Envelope of Discrepancy" as a clinical guideline to aid in defining the borders between the three treatment options of growth modification, camouflage and a combined Orthodontic/ surgical approach. The "Envelope of Discrepancy" describes the ideal position of the upper incisors, represented by the origin of the x and y axes. It shows the amount of tooth movement which could be produced by orthodontic tooth movement alone (the inner envelope of each diagram); orthodontic tooth movement combined with growth modification (the middle envelope) and orthognathic surgery (the outer envelope). The possibilities for movement in each direction is not symmetric as there is more potential to move teeth forward rather than back and for extrusion rather than intrusion. The growth modification envelope for the maxilla and mandible is the same, since they cannot be modified independently of each other. There is a maximum of 10mm potential to advance the maxilla and 15mm retraction compared to surgery to the mandible which has a potential for 12mm advancement and 25mm set back.

2.2.4 Orthognathic Surgery

Combined orthodontic and orthognathic surgical treatment aims to produce more harmonious skeletal and soft tissue relationships as well as improve occlusal function.[23] Dissatisfaction with facial appearance is a large motivational factor in individuals seeking orthognathic surgery.[10, 24 25]

Orthognathic surgery for the correction of class 3 deformity was first introduced in the late 1800's by Edward Angle.[26] The range of skeletal deformities that are correctable through surgery was expanded with the introduction of the sagittal split osteotomy, followed by the Le Fort 1 osteotomy in the 20th century.[27, 28] Further advances in surgical techniques, including the use of titanium plate, and in more recent years digital surgical techniques mean that orthognathic surgery is generally a safe, predictable and stable technique for correction of skeletal deformity. [29]

Unlike other orthodontic treatment modalities, orthognathic surgery aims to reposition the bones of the face in order to correct both the dental and skeletal discrepancies. Surgery can be performed on the maxilla, the mandible or combinations of both jaws to achieve the desired correction. The range of possible movements are extensive as it is possible to reposition the bones in the anteroposterior, vertical and transverse dimensions, (Figure 2).

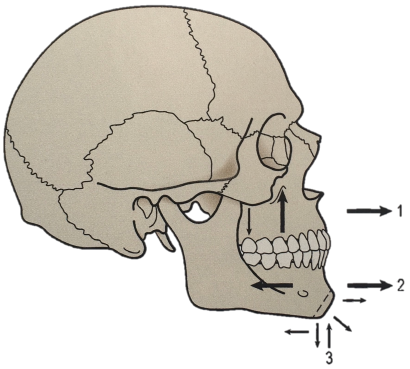


Figure 2: Range of possible surgical movements. (1) The maxilla can be moved forwards, upwards and downwards. (2) The mandible can be moved forwards or backwards. (3) The chin can be moved forwards, backwards, upwards and downwards. (Cobourne, 2016)[30]

Patients seeking orthognathic surgery often report on the negative impact that their dental or facial deformity has on their quality of life.[31,32,33,34,35] They often have the expectation that surgery will improve their self-confidence, body-image and interpersonal relationships as a result of improved social interactions.[36] This has been supported by studies assessing the benefits of orthognathic surgery which have found significant improvements in social interactions, facial and dental aesthetics and masticatory function.[37]

Orthognathic surgery is performed as a multi-disciplinary treatment with the input of both orthodontists and oral and maxillofacial surgeons.

2.3 Class III malocclusion

A class III malocclusion usually refers to the incisor relationship, however it may also refer to the underlying skeletal pattern or molar relationship. As defined by the British Standards Institute (1983), a class III incisal relationship is where the lower incisal edge occludes anterior to the cingulum plateau of the upper incisor and the overjet is reduced or reversed.[15] A class III molar relationship occurs where the mesio-buccal cusp of the upper first permanent molar occludes distal to the buccal groove of the lower first permanent molar.[14] These are classifications of the dental relationship and describe the position of the teeth relative to one another.

The position of the teeth is usually a reflection of the underlying skeletal pattern and a class III incisor relationships is usually a reflection of an underlying class 3 skeletal relationship. A class 3 skeletal relationship is the result of a discrepancy between the anteroposterior positions of the maxilla and mandible, with the lower dental base protruded relative to the upper, and often produces a concave facial profile.[16,38] This can be a result of maxillary retrusion, mandibular prognathism or a combination of both.[39]

2.3.1 Prevalence

The prevalence of class III malocclusion in the general population is low. It is the least common of the four main classifications of malocclusion, however the proportion of the overall population that it comprises varies significantly across different ethnic groups, (Table 2).

The prevalence of class III malocclusion in Caucasian populations is generally <5%. *Foster and Day* (1974) found a prevalence of 1.6% for class III malocclusion amongst British girls aged 11 to 12 years[9], whilst a study by *Haynes* et al. (1970) found a 3.2% prevalence in the same age group.[40] The prevalence increases to between 12-20% in those from South East Asian countries. Those with Chinese ethnicity have some of the highest incidences of class III occlusion.[9, 38, 41-44] A relatively high prevalence of class III malocclusion is also seen in Mediterranean and Middle Eastern populations.[45,46]

2.3.2 Prevalence of class III malocclusion in the orthodontic and orthognathic population

Patients with class III malocclusions are disproportionately represented amongst the orthodontic population due to the unfavourable aesthetics and functional issues that are associated with this type of dental and skeletal relationship. Due to the limited potential for successful growth modification, surgery is often the only option for improvement of the class III skeletal pattern. A study by Baik *et al* (1995), looking at Korean orthodontic patients, found the proportion with class 3 malocclusion to be 41.6%. In the same study, class 3 patients comprised the majority of the orthognathic caseload, 74.3%.[47]

Author	Year	Population	n	% Class III (n)	Age Group	Method of Assessment
Lew *et al*	1993	Chinese	1050	12.76 (134)	Children	Clinical Examination
Tang	1994	Chinese	201	19.9 (40)	Adults	Models
Woon *et al*	1989	Chinese	154	18.18 (20)	Adults and children	Clinical Examination
		Malay	151	12.58 (19)	Adults and children	Clinical Examination
		Indian	42	0 (0)	Adults and children	Clinical Examination
Soh *et al*[44]	2005	Chinese	258	22.87 (59)	Adults and children	Models
		Malay	60	26.67 (16)	Adults and children	Models
		Indian	21	4.76 (1)	Adults and children	Models
Gauba *et al*	1998	Indian	1532	1.17 (18)	Children	Clinical Examination
Perillo *et al*	2010	Italian	703	4.27 (30)	Children	Clinical Examination
El-Mangoury & Mostafa	1990	Egyptian	501	11.38 (57)	Adults	Clinical Examination
Ng'ang'a *et al*	1993	Kenyan	245	5.31 (13)	Adults and children	Clinical Examination
Behbehani *et al*	2004	Kuwaiti	1297	9.48 (123)	Children	Clinical Examination
Sidlauskas & Lopatiene	2009	Lithuanian	587	5.62 (33)	Children	Clinical Examination
Onyeaso	2004	Nigerian	636	11.79 (75)	Children	Clinical Examination
Dacosta	1999	Nigerian	1028	2.04 (21)	Adults and children	Clinical Examination
Otuyemi & Abidoye	1993	Nigerian	574	1.22 (7)	Children	Clinical Examination
Abu Affan *et al*	1990	Sudanese	583	3.43 (20)	Children	Clinical Examination
Diagne *et al*	1993	Senegalese	1708	4.45 (76)	Adults and children	Unknown

Mtaya *et al*	2009	Tanzanian	1601	1.81 (29)	Children	Clinical Examination
Rwakatema *et al*	2006	Tanzanian	289	19.72 (57)	Children	Clinical Examination
Mugonzibwa *et al*	1990	Tanzanian	200	8 (16)	Children	Clinical Examination
		Tanzanian	153	5.23 (8)	Children	Clinical Examination
Gelgör *et al*	2007	Turkish	2329	10.3 (240)	Children	Clinical Examination
Hill *et al*[42]	1959	Caucasian American	*	1.53 (*)	Children	Clinical Examination
			*	0.73 (*)	Children	Clinical Examination
Baik *et al*[47]	1995	Korean	2063	41.6 (859)	Adults and Children (orthodontic patients)	Clinical Examination
Garner & Butt[48]	1985	African American	445	8.7 (34)	Children	Clinical Examination
		Kenyan	505	16.8 (85)	Children	Clinical Examination
Silva & Kang[49]	2001	Latino American	507	9.1 (46)	Children	Clinical Examination
Lew *et al*[43]	1993	Chinese Australian	1050	12.6 (134)	Children	Clinical Examination
Foster & Day[9]	1978	British	1000	3.5 (35)	Children	Clinical Examination
Ingervall B.[41]	1973	Swedish	301	4 (*)	Adults	Clinical Examination

* No data available

Table 2: Prevalence of class III malocclusion in different countries, (modified from Hardy *et al*)[46]

2.3.3 Aetiology of class 3 skeletal pattern

The relative positions of the maxilla and mandible contribute to a class 3 skeletal pattern. These can be divided into pure mandibular protrusion, pure maxillary retrusion and combinations of both.

Maxillary deficiency is found in the majority of patients with a class 3 skeletal pattern.[39, 50] Studies by Ellis and McNamara (1984) and Guyer *et* al (1986) found the prevalence of skeletal maxillary retrusion to be, 65-67% in adults and 55% in children with class 3 skeletal patterns respectively.[39, 50] The maxillary deficiency was associated with mandibular prognathism in 31% of the sample studies, and found in isolation in 19.5%.[39] Pure mandibular protrusion was found in only 19.2% of cases.[39]

The most frequently occurring combinations of maxillary and mandibular anterior-posterior positions which contribute to a class 3 skeletal pattern have been found to be; maxillary retrusion with mandibular prognathism; comprising between 9.5%-30.1% of adult cases, pure maxillary retrusion, with an averagely positioned mandible has be found to occur in 19.5%-37.5% of cases, and pure mandibular prognathism in 19.2%-49%, (Table 3). [39,51,52]

	Age	Maxillary Retrusion	Mandibular Prognathism	Combination of maxillary retrusion and mandibular prognathism
Ellis E., McNamara J. (1984)[39]	Adults	19.5%	19.2%	30.1%
Guyer *et al* (1986)[50]	5-7 year olds 8-10 year olds 11-13 year olds 13-15 year olds	26.3% 25.0% 25.8% 22.9%	26.3% 35.0% 19.4% 17.1%	15.8% 20.0% 19.4% 34.3%
Sanborn R.T. (1955)[51]	Adults	33.3%	45.2%	9.5%
Dietrich (1970) [50]	Adults	37.5%	31%	24%
Jacobson *et al* (1974)[52]	Adults and Children	26%	49%	14%

Table 3: Skeletal variability of class 3 malocclusion

These may also occur on different vertical skeletal bases, or with transverse anomalies, making the presentation of class 3 skeletal discrepancies various and complex. Fifty nine percent of individuals with class 3 skeletal patterns showed reduced or neutral lower facial heights with 41% exhibiting increased lower face height.[50]

There is a lot of variability between reported values, due to the different age ranges and ethnicities of subjects, as well as different methods of recruitment of participants and measurement techniques.

2.3.4 Features of Class III malocclusion

Facially, subjects with Class 3 skeletal discrepancy may present with mid-face deficiency, increased scleral show, malar flattening, malar hypoplasia, paranasal hollowing, an obtuse nasolabial angle, reduced incisor show and increased buccal corridor display on smiling.[53] In patients were there has been dentoalveolar compensation the maxillary incisors tend to be proclined and mandibular incisors show retroclined in an attempt to compensate for the underlying skeletal base. *Riedell et al.* (1952) showed that the lower incisor to mandibular plane angle was reduced in Class 3 individuals at 72° in males and 74.8° in females.[39,54] The degree of proclination and retroclination of the incisors has also been cited as a method of determining whether camouflage treatment may be possible.[55]

Subjects with Class III malocclusion usually exhibit these unique skeletal and dental features from an early age[50] and often present with an unfavourable growth pattern. *Baccetti et al*. (2007) found that Class 3 growth persists well beyond the adolescent growth spurt into early adulthood.[56] A much longer period of active mandibular growth and the lack of maxillary catch up coupled with a more vertical direction of facial growth during late adolescence are unfavourable aspects of Class 3 malocclusion in both genders during the post-pubertal stages.[56]

2.3.5 Treatment options

Treatment options for patients presenting with class 3 malocclusion are dependent on the age, future growth potential, aetiology and severity of the malocclusion and the patients concerns. However, they fall into the same categories as all orthodontic treatment options; growth modification, orthodontic camouflage and orthognathic surgery.

The potential for correction of class 3 relationship with growth modification is limited due to the need to start such treatment early, before the age of 10, and the high patient compliance required.[20] However, correction of class 3 malocclusion can be achieved in approximately 70% of cases by orthopaedic treatment with a facemask.[57,58] These patients often exhibit an unfavourable growth pattern and research has shown that a quarter of patients who have undergone orthopaedic/orthodontic treatment, still required a surgical approach following active growth to address the underlying dentoskeletal discrepancy, as they did not respond satisfactorily to the early intervention.[59,60]

In cases where the underlying skeletal pattern is mild or moderate, correction of the malocclusion may be achieved with orthodontic treatment alone. However, camouflage treatment may be outstripped by future growth or be delayed until growth is completed.

A combined approach involving both orthodontics and orthognathic surgery is often required in order to achieve the ideal correction of the skeletal relationship in non-growing patients. The decision on treatment modality is based on the clinician's assessment of the final result in terms of aesthetics, function and stability but also on the patient's objectives and perception of need.[7] For patients with class 3 skeletal pattern, the method of surgical correction depends on the skeletal aetiology. In general, common movements for class 3 correction include maxillary advancement, mandibular setback or a combination of both.

2.4 Influence of ethnicity on facial aesthetics

Different ethnic groups have different perceptions of what constitutes an aesthetic facial profile. *Mantzikos* (1998)[61] attempted to determine the facial profile preferred by the Japanese population. The sample consisted of 2651 randomly selected panellists from different Japanese cultural and educational backgrounds who had emigrated from Japan to the United States within the previous five years. Five facial profile types were computer-generated to represent distinct facial types. These were orthognathic profile, bimaxillary retrusive profile, bimaxillary protrusive profile, mandibular retrognathic profile and mandibular prognathic profile and the participants were asked to rank the profiles in descending order of attractiveness. The orthognathic profile was shown to be the most preferred with mandibular prognathism being the least favoured.[62] This is surprising considering class 3 skeletal discrepancies, especially associated with mandibular prognathism, are prevalent in Japanese populations. However, as the panelists in the study had moved from Japan to the United States *Mantzikos* (1998) [61] suggests that their views may have been influenced by the media. He discussed that when these Japanese moved to culture where there was a wide variety of racial components, their individual views and concept of beauty were consequently changed. *Mantzikos* (1998) also argued that the orthognathic profile may have been the preferred profile since it appears to simulate profiles of a variety of different ethnic movie actors.[61]

Soh et al. (2005) looked at the perception of male and female Chinese facial profile aesthetics between dental professionals (orthodontists and oral surgeons), dental students and laypersons in an Asian community.[8] A profile photograph and lateral cephalometric radiograph of one Chinese male and female with a normal Class I profile was digitised and modified by altering cephalometric skeletal and dental hard tissue norms by two standard deviations in the anteroposterior plane. This resulted in 7 facial profiles for each sex. The study showed that dental professionals, dental students and laypersons have similar views on male and female aesthetic preferences. Chinese male and female profiles that were normal or had

bimaxillary retrusion were perceived to be the most attractive by all groups and profiles with a protrusive mandible were perceived to be the least attractive. They also found that dental professionals, that is orthodontists and oral surgeons, were less tolerant of a retrusive mandible and that dental professionals, dental students and lay persons were more tolerant of bimaxillary protrusion in females compared to men.[8]

Chong et al. (2014)[12] compared the perception of Caucasian and Chinese judges on the aesthetic lip position of Chinese adults. The sample consisted of 251 Caucasian and Chinese dentists and laypersons in Australia and China who were asked to rank eight profile images. A photograph of a dental and skeletal Class I Chinese adult male and female was digitally manipulated to Chinese and Caucasian mean values. The lip profile was adjusted with the upper and lower lip at the mean distance from Ricketts' E-plane which was used as a baseline. The image was digitally manipulated to produce six additional images to i.e. 0.5, 1.0 and 2.0 standard deviations in front of and behind the E-Plane. A significant difference was found, with the Chinese judges preferring a more retrusive profile and were more likely to rate a protrusive profile as unacceptable, compared with Caucasian judges. This was surprising since the Chinese population norms tend to have more protrusive lips and Chinese assessors might be expected to find a protrusive profile more acceptable. They showed that the ethnicity of the judges was a significant factor influencing the perception of aesthetic lip position. A limitation of the study was that they did not distinguish between native Chinese living in Australia and new immigrant Chinese recently arriving in Australia. This may affect the perception of aesthetics between the groups as the new immigrants may have similar views on aesthetics to the Chinese group.

Previous work by *Maganzin* (2000)[63] investigated the profile preferences of the Chinese population by manipulation of images from one female and one male with Chinese norms. Four disproportional facial profiles were constructed from the initial normal digitized stimulus image, providing a total of 5 profiles to be compared. These disproportional images differed

by 2 standard deviations from the average anteroposterior skeletal and dental values for Chinese adults. They concluded that the Chinese layperson found dental retrusion in an otherwise balanced male skeletal pattern to be as attractive as bi-maxillary protrusion and a total aversion for class 2 skeletal profiles and mandibular prognathism.

2.5 Ethnic anatomical facial variation

Attempts have been made to quantify facial aesthetics through cephalometric analysis. However, differences between ethnic groups and ethnic norms should be taken into consideration when formulating an orthodontic treatment plan for patients of varying ethnic backgrounds. In spite of these possible ethnic differences, most cephalometric studies have been based on sample populations with European-American ancestries. Therefore, it is inappropriate to apply these Caucasian norms to other ethnic groups.

A study by *Miyajima et al.* (1996)[64] did investigate the differences between ethnic groups and compared two groups of adults from different races (Japanese and European-American) who had well balanced faces and normal occlusions. The lateral cephalometric radiographs of 54 Japanese adults (26 men and 28 women) were compared with a sample of 125 adults (44 men and 81 women) of European-American ancestry. The differences between cephalometric measurements between the groups were analysed. In comparison to the European-American sample, the Japanese sample, exhibited smaller anteroposterior facial dimensions and proportionately larger vertical facial dimensions. The facial axis angle was more vertical in Japanese subjects which indicated a more downward direction of facial development. They showed a more acute nasolabial angle as well as bilabial protrusion. They concluded that a fundamental variation exists in the craniofacial structure of Japanese and European-Americans. This study reinforces that a single standard of facial aesthetics is not appropriate for application to diverse racial and ethnic groups.

A review of the available cephalometric studies of Chinese patients found the main differences between Chinese and Caucasian hard tissue values were; a shorter anterior cranial base, an increased lower incisor to mandibular plane angle and a smaller inter-incisal angle in the Chinese[65] (Appendices I-II). The soft tissue analysis found a protrusive upper and lower lip in the Chinese patients, which appeared exaggerated as the nose and chin are less prominent [65] (Appendices III-IV).

2.6 Soft tissue analysis

Evaluation of the patient's soft tissue profile is an important component of orthodontic treatment planning. It is especially important in patients considering combined orthognathic treatment as the soft tissues will be altered by the position of the underlying skeleton. Leslie Farkas, established anthropometric craniofacial measurements for North American whites and in later work compared data from 25 countries across the world to these Caucasian norms.[66-69] The study group consisted of 1470 healthy subjects (18 to 30 years), 750 males and 720 females drawn from five regions in the world: Europe, the Middle-East, Asia, Africa and North America. The largest group (780 subjects, 53.1%) came from Europe (13 countries), all of them Caucasians. Three countries were represented from the Middle-East (180 subjects, 12.2%), five countries from Asia (300 subjects, 20.4%) and 210 subjects, 14.3% had an African origin including African-Americans in the United States. They carried out 14 anthropometric measurements in order to establish the normal range of measurements of the craniofacial complex in all participating ethnic/racial groups which included establishing Chinese norms. *Farkas et al*. anthropometric craniofacial measurements for Caucasian and Chinese males and females are attached in Appendices I and II.

Arnett et al. (1999)[70] also recognised the importance of soft tissue profile in treatment planning. They developed a soft tissue cephalometric analysis which was a further development from earlier work on "Facial Keys". The soft tissue cephalometric analysis was not meant as a stand-alone analysis but could be used alongside clinical examination and other cephalometric analyses to provide clinical soft tissue information to aid treatment planning. However, this analysis was based on only 20 Caucasian males and 26 Caucasian females therefore it is not applicable to other ethnic groups.

A number of previous studies have compared Chinese cephalometric standards with those of Caucasian norms. One such comparison study which analysed both the dentoskeletal and

soft tissues was carried out by *Cooke et al*. (1987)[71] which compared the cephalometric radiographs of 120 Chinese with 20 Caucasian 12 year old males in Hong Kong. They found that the Chinese soft tissue profile displayed a more obtuse and less prominent nose and chin. However, the upper and lower lips were more protrusive and the upper lip was longer. When the Caucasian and Chinese profiles were superimposed on the nose and forehead it showed similar profiles down to the nose tip, below which the Chinese profile displayed more protrusion of the nose and lips.

Lew et al. (1992)[72] attempted to develop soft tissue guidelines for Chinese adults for use in such patients seeking Orthodontic or orthognathic surgery treatment for dentofacial disharmonies. The analysis was based on seventy-two Chinese subjects (36 men, 36 women) aged between 18 to 24 years (mean, 21.1 +/- 1.9 years) with harmonious facial profiles and the presence of an intact dentition. They concluded that Chinese profiles generally have a less convex profile, a more retruded maxilla, a less obtuse nasolabial angle and a more protrusive upper lip compared to Caucasians.

2.7 Clinicians' perception of the need for orthognathic surgery

Dental professionals tend to be more sensitive in their judgement than lay persons due to their training, educational background, and knowledge of facial deformity. Additionally, dentists appear to have a greater ability to discriminate profile changes due to observing more extreme deviations from normal.[73]

Previous research has looked at the influence of soft tissue landmarks on helping orthodontists and oral and maxillofacial surgeons to determine whether they would recommend orthognathic surgery for a particular patient. Work by *Naini et al. (2012)*[74] looked at the influence of the sagittal chin prominence on perceived attractiveness and to determine the clinically significant threshold value beyond which treatment is desired through the use of silhouettes. An ideal facial profile silhouette image was created and chin prominence altered in 2 mm increments from -24 to 12 mm, in order to represent retrusion and protrusion of the chin, this was used to investigate the difference in perception of attractiveness between clinicians (oral and maxillofacial surgeons and orthodontists), patients and lay people. They found that up to 4mm of chin retrusion and protrusion was essentially unnoticeable. Clinicians would recommend surgery for patients with chin protrusion greater than 6mm and chin retrusion of greater than 10mm. In relation to perceived attractiveness they did not find a statistically significant difference between clinicians and orthognathic patients or clinicians and laypersons.

Naini et al. (2012)[75] also looked at the influence of mandibular prominence on perceived attractiveness between clinicians that is oral and maxillofacial surgeons and orthodontists involved in care of patients with facial deformity, orthognathic patients and lay people. An ideal facial profile silhouette image was altered in 2mm increments from -16mm to 12mm from ideal Caucasian norms, in order to represent retrusion and protrusion of the lower jaw. They were asked to rate attractiveness using a Likert type scale and also whether they would recommend surgery or not. Mandibular retrusion of up to -4mm and protrusion of up to 2mm was essentially

unnoticeable. Clinicians recommended surgery from mandibular protrusion greater than 5mm and retrusion greater than -8mm. However orthognathic patients and laypeople were more critical and desired surgery from mandibular protrusions of greater than 3mm. All observer groups shared the same aesthetic opinion that the greater the retrusion or prominence of the lower jaw, the less attractive the perceived attractiveness and the greater the desire for surgical correction. *Naini et al.* (2012)[75] concluded that in treatment planning an ideal sagittal position of soft tissue pogonion on or just behind a true vertical line through subnasale may be used.

A further study by *Naini et al.* (2012)[76] looked at the influence of lower facial profile convexity on perceived attractiveness in the same groups of orthognathic patients, clinicians (19 Maxillofacial surgeons and 16 Orthodontists) and laypersons. A facial silhouette image was manipulated in terms of lower facial profile from ideal Caucasian norms in 2˚ increments from 14˚ to -16˚ and observers used a Likert type scale to rate the level of attractiveness and need for surgery. They found that the rating decreased for every degree of increase in facial profile convexity indicating that a convex profile is perceived as least attractive and a straight profile was seen as the most attractive. Patients were more critical than clinicians and laypersons in the desire for surgery. With increasing concavity of the profile, the odds of desire for surgery was 69% less for clinicians compared to orthognathic patients.

Work by *Juggins et al*. (2005)[10] investigated patient and clinician perceived need for orthognathic treatment. Forty patients were asked to rate their perceived need for treatment and 40 clinicians (20 Orthodontists and 20 Oral and Maxillofacial surgeons) were also asked to rate the need for treatment using study models and clinical photographs. This questionnaire based study showed significant differences between patients and clinicians in perceived need for treatment based on facial appearance with clinicians rating a greater need for treatment. There was large variation between the Orthodontist and Oral and Maxillofacial group with the latter rating a significantly greater need for treatment based on facial appearance and function.

However large variations existed in both clinician groups and therefore the results must be viewed with caution.

A study by *Almeida et* al (2009)[77] looked at the association between the anteroposterior position of the mandible and the perceived need for orthognathic surgery. They took into account racial differences and used photographs of four adults with accepted facial balance both antero-posteriorly and vertically which included one Black male, one Black female, one Caucasian male and one Caucasian female. Their photographs were altered to produce a straight profile and 6 simulations of mandibular discrepancies; that is 3 images retruded from the original profile and 3 images protruded from the original. In total 28 photographs were evaluated by Orthodontists, Oral and Maxillofacial surgeons, artists and laypersons. The study showed that males with a convex profile and females with concave profiles are perceived as having a greater need for surgery. Laypeople were the most tolerant to changes in profile with Maxillofacial surgeons being the least tolerant to profile changes. When racial differences were considered there was no statistically significant difference in the number of indications for surgery between photographs of Black or Caucasian individuals.

Research by *Hodge et al.* (2012)[23] explored Orthodontist's perceptions of the need for orthognathic surgery in patients with Class II division I malocclusion based on extra-oral examinations. A questionnaire containing 40 profile photographs of adults with Class II division I malocclusions was posted to all 256 UK Consultant Orthodontists and they were asked whether "based on the profile view of the patient would they treat using a combined Orthodontic-Surgical approach". The study concluded that facial profile angle and the positions of soft-tissue pogonion and B point are useful clinical guides for planning these patients. This study however did not take into account the perception of oral and maxillofacial surgeons in determining the need for orthognathic surgery.

2.8 Facial Identification

Clinical images are an essential tool in orthodontics and form a key part of a patients' confidential clinical records. These are used for assessment of the initial presenting malocclusion, for post-treatment changes and are a useful tool for communication between clinicians.

Everyone has a unique facial appearance which may be readily identifiable by others. This can pose potential difficulties for the use of facial images in research due to reasons of confidentiality. There are many methods of de-identification of facial images for use in research; blocking out of identifiable facial features such as eyes, changing elements such as hairstyle, cropping the image to the profile only, using line-drawn outlines of profiles or using silhouettes. Complete clinical photographs are more realistic than silhouettes or cropped views and better facilitate clinical assessment as the whole profile is visible. A study by Shi *et al* (2016) demonstrated that colour profile photographs were better perceived by raters that either silhouettes or black and white photographs.[78]

A method of retaining the benefit of colour photographs whilst maintaining patient anonymity is through the use of composite images. There are multiple effective methods of creating composites including using different facial features from multiple photographs to create a new image, or from mathematical averages of multiple photographs.[79, 80] Engelstad *et al* (2011) showed that when presented with composite images of individuals familiar to themselves study participants were unable to recognise these unless primed to their presence.[79] Morphing is the creation of averages through a mathematical process, usually performed using computer software. Average profile images created through morphing have been found to be rated more attractive than those of individual patients with exactly the same profile.[80] The use of averages reduces some of the variability that can occur when using images of individuals.

Warping is the distortion of one static image to produce another static image.[81] Image warping can be used in dentistry to demonstrate possible treatment outcomes to patients, especially orthodontics. Visualised treatment objective (VTO) software utilises this technique when creating predictions of treatment outcomes for patients considering orthognathic surgery.[81] Although usually utilised for demonstrating possible outcomes after correction of facial deformity, it can also be used for creating images with different degrees of skeletal deformity for research purposes.[8, 82-84]

2.9 Rationale for the study

2.9.1 Previous Studies

Previous studies have concentrated on how soft tissue landmarks influence clinician's decisions to recommend orthognathic surgery for Caucasians and they do not necessarily take into account the possible influence of accepted racial norms on clinician's judgements. A recent DDSc project completed in Liverpool University Dental Hospital by Al Rashidi *et al.*[84] investigated the effect of patient's ethnicity on clinical decision making. The study utilised two different profile silhouettes; female Caucasian and female Chinese which were manipulated in Adobe Photoshop to create increasingly class 3 profiles, (Figure 3). The maxilla and mandible were manipulated individually in 2mm increments up to a maximal 10mm discrepancy in each jaw. The images were included in a questionnaire distributed to consultant orthodontists and oral and maxillofacial surgeons in the United Kingdom. The questionnaire asked the respondents whether they felt that the profile would benefit from surgery and how attractive they would rate it.

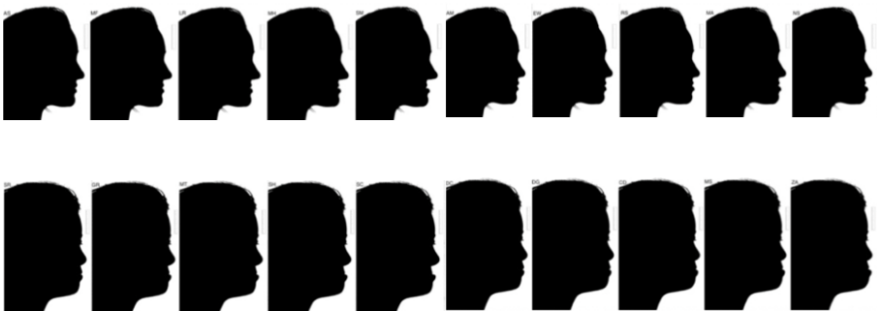


Figure 3: Manipulated female Caucasian and Chinese silhouettes used by Al-Rashidi[84]

The results of the study demonstrated that for manipulations greater than 6mm there was 100% agreement amongst clinicians as to the benefit from surgery. There were no statistically significant differences between orthodontists and oral and maxillofacial surgeons. The only statistically significant factor that influenced benefit from surgery was ethnicity with the odds

of being recommended for surgery 2.87 times higher for Chinese than Caucasian silhouettes.

However, there were limitations to the study both in the use of silhouettes, rather than colour photographs, and the sample frame. In the United Kingdom there is a relatively low prevalence of both clinicians and patients of Chinese ethnicity. Therefore, clinicians may have limited experience in management of class 3 malocclusion in patients of Chinese ethnicity in comparison to Caucasians. As has been discussed, ethnicity of both clinician and patient may influence the perception of the need for orthognathic surgery.

2.9.2 Current Study

In this study composite average profile photographs were used rather than silhouettes a more realistic representation of clinical assessment of a patient. This study also expanded the number of profiles to include both males and females. It has been shown that photographic records provide valid, reproducible and representative ratings of dental and facial appearance.[85, 86] The use of composite averages from clinical photographs reduces potential issues relating to patient identification and facilitates more meaningful attractiveness rating comparisons than if using single patient images. However, an increased level of ethical approval was required due to the use of patient data for this method.

In the previous study by Al Rashidi *et al* (2016) the maximum manipulation was 10mm as this is the limit for surgical advancement of the maxilla as proposed by *Proffit et al*. (2000).[84, 87] However, there was complete agreement between all clinicians on the potential need for surgery for manipulations greater than or equal to 8mm.[84] Therefore, in order to reduce the number of images presented in the questionnaire the maximum manipulation was limited to 6mm in both the maxilla and the mandible. This study study aimed to explore the extent to which maxillary retrusion and mandibular prognathism influences whether clinicians recommend surgery or not and investigate whether the patient's ethnicity influences clinician's

decision making in recommending orthognathic surgery.

A limitation of the previous study, which was undertaken in the United Kingdom, was that there were limited clinicians of Chinese ethnicity who participated. In Hong Kong there is a majority ethnically Chinese population (92%) with a small Caucasian population (1%) mostly made up of expatriate workers and their families.[88] This situation mirrors that which is present in the United Kingdom; 0.8% Chinese and 86% Caucasian according to the most recent census.[89]. Therefore, this study targeted orthodontists and oral and maxillofacial surgeons in both the United Kingdom and Hong Kong in an attempt to increase the external validity of the study.

2.10 Data Collection

Scott et al. (2011)[90] investigated the effects and costs of three different modes of survey administration in a national survey of doctors. The three different modes were online questionnaires, simultaneous mixed mode questionnaires which consisted of a paper questionnaire and online login details which were sent together and thirdly a sequential mixed mode method which consisted of an online version followed by a paper questionnaire with a reminder. *Scott et al*. (2011)[90] found that sequential mixed mode method resulted in a significantly higher response rate compared to the online mode and it also received a higher response compared to the simultaneous mixed mode method. They also showed that the sequential mixed mode method compared to the other techniques was more cost effective.

Online surveys have many advantages including respondent anonymity. Participants feel more comfortable in providing feedback when it is confidential and this increases response and completion rates.[91,92] However other studies have shown that postal questionnaires have a higher response rate compared to online questionnaires.[93] This highlights that each method has advantages and disadvantages therefore a sequential mixed mode approach should give the best opportunity to maximise response and completion rates as it offers an alternative response if participants prefer one method over the other.

The questionnaire design has also been shown to influence the response rate. A comparison of surveys of varying length found a threshold of 1000 words, after which response rates start to tail off.[94] This along with other studies shows that the shorter the survey, the higher the repose rate. [95-98] Use of close-ended questions compared to open-ended questions have been shown to result in a 22% increase in response rate.[99] *Flanigan et al.* (2008) carried out a literature review of the conduct of surveys among physicians which concluded that higher response rates are obtained if the survey is relevant to the participant's clinical practice/ area of medicine.[100]

In order to maximise our response and completion rate we used a sequential mixed mode approach where possible, close ended questions and attempted to keep the questionnaire as short as possible without compromising the study quality.

3. Aims and Objectives

3.1 Research question

Does the racial background of the patient influence clinicians' perception of the potential benefit from orthognathic surgery in patients presenting with class 3 skeletal discrepancies?

3.2 Aim

To investigate the impact of patients' race on clinicians' perception of facial attractiveness and whether this influences their assessment of the potential benefit from orthognathic surgery in patients with class 3 skeletal profiles.

3.3 Objectives

1. To compare clinicians' assessment of which class 3 skeletal profiles would be recommended for orthognathic surgery in patients of Caucasian and Chinese origin.
2. To investigate whether orthodontists and oral and maxillofacial surgeons have similar views on the need for orthognathic surgery.
3. To identify which profile clinicians rate as most attractive for:
    - Caucasian patients (male and female)
    - Chinese patients (male and female)
4. To identify any clinician related factors that might influence their decisions including:
    - Length of time since specialist qualification
    - Gender
    - Ethnicity
    - Specialty i.e. orthodontist or oral and maxillofacial surgeon

- Location of work
- The number of orthognathic patients treated each year

5. To investigate whether clinicians' personal values of facial attractiveness influence their decision making on the need for orthognathic surgery.

3.4 Null Hypothesis

- Ethnicity does not influence clinicians' decision making as to the need for orthognathic surgery for patients presenting with class 3 skeletal patterns.
- There is no difference between orthodontists and oral and maxillofacial surgeons perception of the need for orthognathic surgery in patients of Caucasian or Chinese ethnicity.

4. Method

4.1 Study design

The study was a prospective cross-sectional observational questionnaire distributed in two locations; the United Kingdom and the Hong Kong Special Administrative Region of the People's Republic of China (Hong Kong SAR). The questionnaire was distributed from April 2018 to September 2018 in the United Kingdom and April 2018 to May 2018 in Hong Kong.

4.2 Target Population

The target population for the study was consultant orthodontists and oral and maxillofacial surgeons in the United Kingdom, and specialist and trainee orthodontists and oral and maxillofacial surgeons in Hong Kong.

There were a total of 320 consultant orthodontists registered with the BOS and 49 consultant oral and maxillofacial surgeons with a specialist interest in facial deformity members of BAOMS in 2018.[101, 102] The deformity group include oral and maxillofacial surgeons who are interested in orthognathic surgery, cleft and craniofacial surgery. This group consisted of 15% of oral and maxillofacial surgeons who are members of the BAOMS. There were 65 specialist orthodontists and 59 specialist oral and maxillofacial surgeons registered with the Hong Kong Dental Council and members of the Hong Kong Society of Orthodontists (HKSO) and the Hong Kong Association of Oral and Maxillofacial Surgeons (HKOMS) in 2018.[103, 104]

4.3 Ethical Approvals

In the United Kingdom ethical approval was sought and obtained through proportionate review with the NHS Research and Development Office. The study was given the REC reference number: (17/LO/1841), (Appendix V). Study sponsorship was obtained from the University of Liverpool (1640), (Appendix VI). Approval for questionnaire distribution was obtained from the Audit Committee of the British Orthodontic Society and the chair of the Facial Deformity Special Interest Group at the British Association of Oral and Maxillofacial Surgeons.

In Hong Kong ethical approval for the study was sought and obtained through the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB), (Appendix VII). The study was given the IRB reference number: (UW 18-260). Recognition of international ethical approval was sought and received from the University of Liverpool (3624), (Appendix VIII).

4.4 Sample Size Calculation

The sample size was calculated based on a previous study carried out by *Al Rashidi* et al.[84] The study was powered to detect a difference in the ratings for benefit of surgery between Caucasian and Chinese silhouettes. The sample size calculation showed a sample size of 158 would allow detection of a difference of 6% between the average overall ratings of the Caucasian and Chinese silhouettes, adjusted for the clustering of ratings within raters, with 80% power, and $\alpha = 0.05$. Therefore, in this study we will aim for a minimum target response size of 158. Total population sampling was carried out, with the potential number of respondents dictated by the total number of members of the BOS, BAOMS, HKOS and HKOMS, which was approximately 550 combined.

4.5 Mode of Questionnaire Distribution

A sequential, mixed mode questionnaire format was used to distribute the questionnaire to consultant orthodontists in the UK. The initial distribution was carried out via email to all members of the Consultant Orthodontist Group (COG) of the British Orthodontic Society (BOS). The e-mail contained a copy of the invitation letter and a link to complete the questionnaire online. Two reminder e-mails were sent; one at 28 days and the other two weeks after the distribution of the paper questionnaire.

The paper questionnaire was posted to all members of the Consultant Orthodontist Group of the British Orthodontic Society with a pre-paid self-addressed envelope for return of the questionnaire. The paper questionnaires were posted 3 months after the initial e-mail invitation was sent. The questionnaires were not numbered so non-respondents, could not be identified upon return and so no postal reminders were sent. An e-mail reminder was sent two weeks after the postal distribution, this also included a link to the online questionnaire if respondents preferred to complete the questionnaire in this way.

The British Association of Oral and Maxillofacial Surgeons do not facilitate paper questionnaire distribution, therefore there was a single online mode of distribution of the questionnaire to consultant oral and maxillofacial surgeons in the UK. The invitation letter with a link to complete the online questionnaire was placed in the 'Facial Deformity Forum' in the members only section of the British Association of Oral and Maxillofacial Surgeons webpage. This generated an e-mail which was sent to members with a special interest in facial deformity surgery. A reminder was placed in the forum, which generated an automatic email to members, after 7 days. A further reminder email was sent directly to individual consultant oral and maxillofacial surgeons with a special interest in facial deformity and orthognathic surgery, 4 weeks after the last forum reminder.

4.5.1 Distribution of the Questionnaire in Hong Kong

For logistic reasons single mode questionnaire distribution was carried out in Hong Kong for both orthodontists and oral and maxillofacial surgeons. A copy of the invitation letter and link to the online questionnaire was emailed to all trainee and specialist members of the Hong Kong Society of Orthodontists and the Hong Kong Association of Oral and Maxillofacial Surgeons. The initial e-mail was followed by two reminders at 14 and 28 days. No incentives were given for completion.

4.6 Questionnaire

4.6.1 Questionnaire format

The design and hosting of the online questionnaire was carried out using SurveyMonkey, accessible at www.surveymonkey.com.[105] The questionnaire was formatted so that it could be completed on multiple devices; smartphone, tablet and computer. The paper version was created using a pdf printout of the randomised SurveyMonkey questionnaire. The content of the web based and paper questionnaire was the same.

4.6.2 Invitation letter

An invitation letter was included at the start of the online SurveyMonkey and paper based questionnaires, (Appendix IX). It provided information in relation to the title of the study, aims and objectives and instructions on how to complete the questionnaire. It aimed to reassure responders about the anonymity of the data and give them the opportunity to decline to participate.

The instructions were:

To spend no more than 30 seconds looking at each silhouette and then answer either “yes” or “no” to the following questions:

1. “Based on the profile picture of this patient alone, do you feel this patient would benefit from an orthognathic surgical approach?
2. “How do you rate the level of attractiveness of the profile?”

The letter also included information about the consent process for the study. Completion of the questionnaire was taken as the respondent consenting to participate in the study. The same invitation letter was included at the start of the paper copy of the questionnaire distributed to members of the Consultant Orthodontist Group (COG) of the British Orthodontic Society (BOS).

4.6.3 Questionnaire design

The questionnaire was divided into four sections (Appendix XI):

- Sections 1 and 2

Enquired about demographic data such as age, gender, ethnic origin, occupation, place of work, number of years since qualification and the number of orthognathic patients personally treated each year.

- Section 3

Questions related to how respondents would rate the attractiveness of their own facial appearance, and the importance they would place on facial appearance.

- Section 4

Include composite images of 'ideal' Caucasian and Chinese male and female profiles and six manipulated images of each. It will also consist of a single duplicate profile photograph of each male and female Caucasian and Chinese profile which will be used to check intra-rater reliability. In total there will be 32 profile photographs and under each image there will be two questions:

Question 1: "Based on the profile picture of this patient alone, do you feel this patient would benefit from an orthognathic surgical approach?"

Question 2: "How do you rate the level of attractiveness of the profile?"

4.6.4 Randomisation

To reduce potential bias, the order of the images in section 4 of the questionnaire, and their corresponding questions, were randomised using multi-level block permutation. Within-block and whole-block randomisation was applied (Figure 4); [106]

Whole-block randomisation

1. The order of the image groups (female Caucasian, male Caucasian, female Chinese and male Chinese) were randomised; with 24 possible order combinations.

Within-block randomisation

2. The order of the seven manipulated images and single duplicate image, were then randomised within each of the image groups; with 40,320 possible order combinations.

New randomisation was automatically applied by SurveyMonkey each time the online questionnaire was opened. This ensured that the order of the images was individual to each respondent. Randomisation was applied by SurveyMonkey prior to downloading the pdf paper copy. All paper questionnaires were randomised, however the question order was the same for all paper questionnaires distributed.

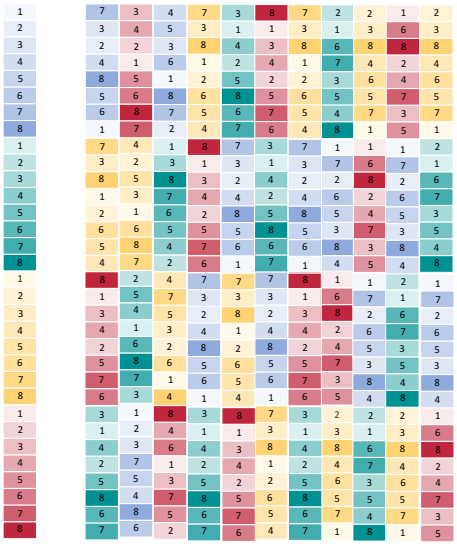


Figure 4: Example of within-block and whole-block randomisation. 11 examples are shown.

4.6.5 Modifications to the questionnaire distributed in Hong Kong

For the Hong Kong version of the SurveyMonkey questionnaire an additional cover letter was included on the first page, (Appendix X). This was to conform to the regulations of the Hong Kong Institutional Review Board and included the local contact details for the study.

The same SurveyMonkey questionnaire used in the United Kingdom study was used in the Hong Kong study with some minor amendments to sections 1 and 2 to reflect the differences between practice in the United Kingdom and Hong Kong (Appendix XII):

- Question 4: 'How many years have you been a consultant?' amended to 'How many years have you been a specialist?'.
- Question 5: 'Consultant Orthodontist' changed to 'Specialist Orthodontist' and 'Consultant Oral and Maxillofacial Surgeon' changed to 'Specialist Oral and Maxillofacial Surgeon'. Additional options of 'Orthodontic Trainee' and Oral and Maxillofacial Surgery Trainee' added.
- Question 7: 'In which UK region do you work predominantly' changed to 'In which area of Hong Kong do you work predominantly', and the drop down options changed to reflect the 18 Hong Kong administrative districts.

4.7 Composite Image Creation

Composite profile images were used in section 4 of the questionnaire to reduce the subjectivity of assessment and risk of patient identification. The decision to use profile images was made to ensure that the simulated scenario was a close as possible to the real-life clinical situation. Average faces are generally rated more attractive than those of individuals, therefore, using composite averages would reduce some of the subjectivity that may occur for the measure of facial attractiveness.[80] The use of averages also preserved patient anonymity and increased the generalisability of the results.

4.7.1 Photograph Identification

A series of standardised extra-oral facial photographs are taken as part of routine records before and after orthodontic treatment for all patients. A right profile view, taken in the natural head position with the Frankfort plane parallel to the floor, is taken as part of the series. These images are stored securely on the J: drive of The Royal Liverpool University Hospitals NHS Trust networked computers, accessible from The Royal Liverpool University Dental Hospital. The 16 profile photographs used in the study were identified from this photograph database.

Inclusion Criteria

- Consent for photographs to be used for research purposes
- >16 years of age
- Caucasian or Chinese ethnicity with average vertical proportions based on Farkas *et al* soft tissue norms.[36,37,38,39]
- Class I skeletal profile
- Good quality image; natural head position, lips in repose, eyes open, no hair over face or ear

Exclusion Criteria

- Poor quality image; hair covering face, facial hair, ear not visible, lips apart, out of focus, poor exposure
- Mixed race or uncertain racial origin
- Cleft lip or palate/craniofacial syndrome
- Identifiable facial birthmarks

Four profile photographs, for patients who met the inclusion and exclusion criteria, were identified for each of the following:

- Male Caucasian
- Female Caucasian
- Male Chinese
- Female Chinese

Sixteen photographs were identified in total. All patients had previously given consent to have their facial photographs used for research purposes.

4.7.2 Creation of the average composites

The composite average profile images were created in Psychomorph facial averaging software from the previously identified patient images.[107, 108] The software is routinely utilised by psychology researchers who need to use human faces in research studies investigating facial expression and attractiveness. By placing fiducial points to delineate the facial features such as; eyes, nose, mouth, ears, the surface of the face is segmented through a process of tessellation so that it can be manipulated by the software into a different shape.

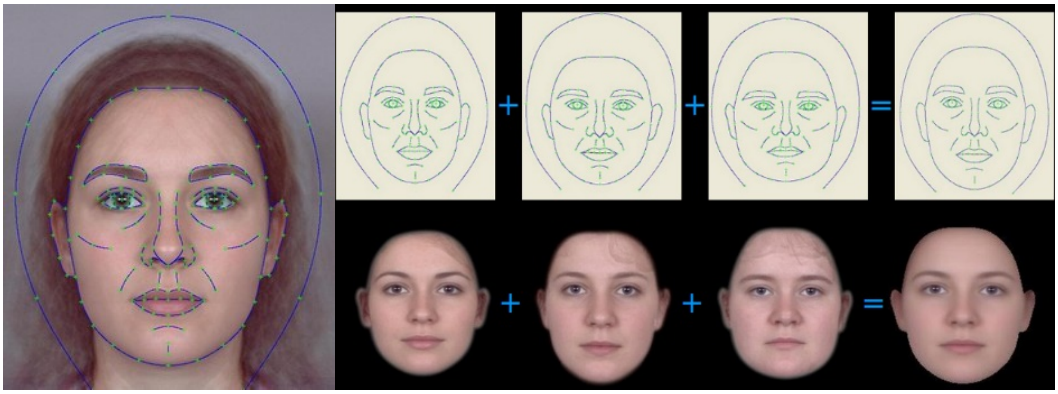


Figure 5: Example of the placement of fiducial points and tessellation to create a facial average (frontal view) in Psychomorph software

To make an average of the faces, as in Figure 5, the software moves the fiducial points of the three faces into the mid-point location across each image and then blends together the brightness and colour values of each pixel in the corresponding tessellated region and produces an average of the three faces.[108]

Facial averaging using this software has always been performed on images taken in frontal view, however for this study a profile view was necessary. A new profile template of fiducial points was created and used on each image a composite average of the side, profile views was achieved, (Figure 6).

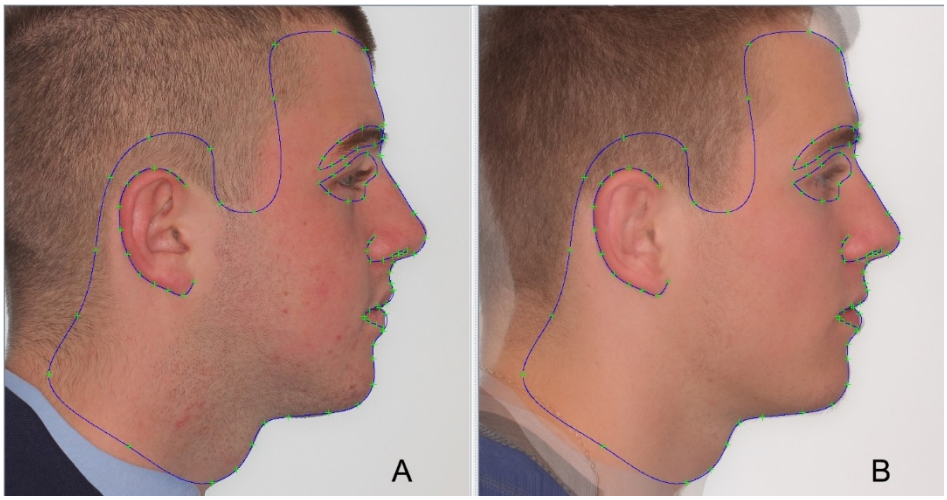


Figure 6: Initial patient image with profile template (A); averaged image (B)

Each composite image was created from a combination of four initial individual patient profile images, (Appendix XIII).

4.7.3 Image Clean-Up

Following averaging of the images, discrepancies in hairstyle, clothing, neckline and eye clarity were present, (Figure 7a). Adobe Photoshop CS6 Extended was used to improve the neckline, ear and eye clarity and to add a singular hairstyle and clothing to normalise the images, (Figure 7b). No adjustments were made to the profile itself.

(a) **(b)**

Figure 7: Raw composite image (a) and image after clean-up (b)

4.7.4 Assessment against Farkas Norms

The proportions of the averaged images were checked against the Caucasian and Chinese Asian Farkas norms (Appendix XIV) to ensure that they conformed to their individual gender and racial norms. The composite images were printed to scale and the distance between the designated soft tissue points (Figure 8) were measured in millimetres (mm). All images conformed to within 1 standard deviation (SD) of the average Farkas norms. These images formed the baseline from which all of the other images were created.

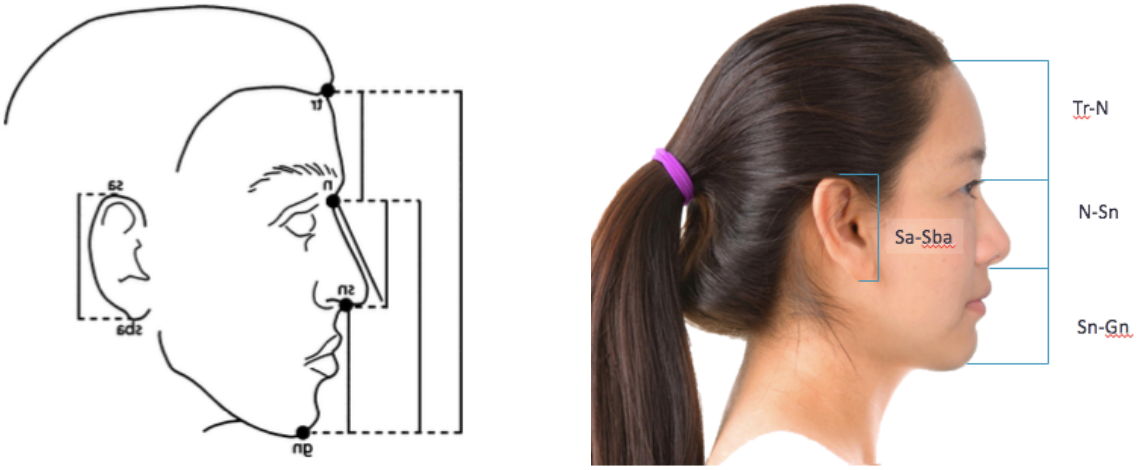


Figure 8: Assessment of proportions using standard points compared against Farkas norms

4.7.5 Composite Image Manipulation

The four average composite images (female Caucasian, male Caucasian, female Chinese and male Chinese) were each manipulated to create incrementally severe class 3 profiles using Adobe Photoshop C6 Extended: [109]

- The maxillary position was manipulated posteriorly from the baseline (0mm) in 2mm increments; -2mm, -4mm and -6mm.
- The mandibular position was manipulated anteriorly from the baseline (0mm) in 2mm increments; +2mm, +4mm and +6mm.

In total 7 composite photographs were created for each group, including the baseline composite image, 28 images in total, (Figure 9, Figure 10, Figure 11, Figure 12).

The accuracy of the anteroposterior manipulation of each image was checked by adding a fixed, known distance marker to the images, printing these to life-size scale and measuring the 2mm directly with a 0.25mm increment ruler.

Figure 9: Manipulated Caucasian male composite images: 0mm, mandible +2mm, +4mm, +6mm, maxilla -2mm, -4mm, -6mm.

Figure 10: Manipulated Caucasian female composite images: 0mm, mandible +2mm, +4mm, +6mm, maxilla -2mm, -4mm, -6mm.

Figure 11: Manipulated Chinese female composite images: 0mm, mandible +2mm, +4mm, +6mm, maxilla -2mm, -4mm, -6mm.

Figure 12: Manipulated Chinese male composite images: 0mm, mandible +2mm, +4mm, +6mm, maxilla -2mm, -4mm, -6mm.

4.8 Outcome Measures

The primary outcome measure for the study was the clinician's perception of the need for orthognathic surgery for each of the images which was measured on a dichotomous 'yes' or 'no' scale. The secondary outcome was the clinicians' perception of the level of attractiveness of each of the images which was measured on a 7 point Likert type scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive or unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

4.9 Piloting the questionnaire

The questionnaire was piloted on orthodontic speciality trainees at Liverpool University Dental Hospital to ensure validity. It was distributed to 2 senior and 10 speciality orthodontic registrars. Online and paper copies of the questionnaire were used to critique the questionnaires content and layout. The functionality of the questionnaire on different devices; desktop, tablet and smartphone was assessed. Feedback was considered and relevant changes made to the functionality of the SurveyMonkey questionnaire, including the activation of the 'other' choices.

4.10 Retrieval of results

4.10.1 Online

The results of the completed online questionnaires were downloaded from SurveyMonkey in Excel and SPSS file formats.

4.10.2 Paper

The returned paper questionnaires were numbered before being transcribed into Excel Spreadsheet by a single operator (JV). 10% (12) of the questionnaires were selected using a random number generator and re-transcribed.[110] The intra-rater reliability was then assessed against these.

4.11 Statistical analysis

Statistical analysis was carried out using SPSS (Version 24.0, Armonk, NY), SAS® software and StatsDirect software.

4.11.1 Response rate

The response rate was calculated form the number of completed questionnaires compared with the number of individuals it was distributed to. Response rate was calculated for the overall study population and for the UK and HK respondents individually.

4.11.2 Demographic assessment

Demographic analysis of the respondents was performed using SPSS. These were calculated for the overall study population and for the UK and HK respondents individually

4.11.3 Intra-rater reliability

- The intra-rater reliability for the benefit from surgery was calculated using kappa statistics in SPSS. The -6mm duplicate image included in the questionnaire was used.
- The intra-rater reliability for the attractiveness ratings were calculated as a weighted-kappa in StatsDirect. The rating for the -6mm duplicate image included in the questionnaire was used.
- These were calculated for the overall study population and for the UK and HK respondents individually

4.11.4 Assessment of the potential benefit from surgery

- The proportion of clinicians who rated each image as potentially benefitting from surgery was calculated using Excel and displayed in a graphical form.
- Multi-level logistic regression analysis was undertaken using PROC GLIMMIX in SAS to determine which factors influenced the raters' assessment as to whether surgery would be of benefit for each image. The effects of racial group, amount of maxillary / mandibular manipulation, and clinician effects including; specialty, gender and ethnicity were modelled for. The clustering was measured by the intra-cluster correlation coefficient.
- These were calculated for the overall study population and for the UK and HK respondents individually

4.11.5 Assessment of the attractiveness ratings of the images

- Means and standard deviations for the attractiveness ratings for each of the composite images were calculated using Excel and the results displayed in graphical form.
- Multivariate linear regression analysis was performed using PROC MIXED in SAS to determine the factors influencing the raters' assessment of the image's attractiveness. The effects of racial group, amount of maxillary / mandibular manipulation, and clinician effects such as specialty, gender and ethnicity were modelled for. The clustering was measured by the intra-cluster correlation coefficient.
- These were calculated for the overall study population and for the UK and HK respondents individually

The study compared clinician's perception of the need for orthognathic surgery in patients of two racial backgrounds (Caucasian and Chinese) who present with Class 3 skeletal discrepancy. The following comparisons were made:

- UK Orthodontists' perception for the potential benefit from surgery for Caucasian skeletal class 3 profiles versus Chinese skeletal class 3 profiles.
- UK Oral and Maxillofacial surgeons' perception for the potential benefit from surgery for Caucasian skeletal class 3 profiles versus Chinese skeletal class 3 profiles.
- UK Orthodontists' perception for the potential benefit from surgery for Caucasian skeletal class 3 profiles versus maxillofacial surgeons' perception for the benefit from surgery for Caucasian skeletal class 3 profiles.
- UK Orthodontists' perception for the potential benefit from surgery for Chinese skeletal class 3 profiles versus maxillofacial surgeons' perception for the benefit from surgery for Chinese skeletal class 3 profiles.
- Hong Kong orthodontists' perception for the potential benefit from surgery for Caucasian skeletal class 3 profiles versus Chinese skeletal class 3 profiles.
- Hong Kong Oral and Maxillofacial surgeons' perception for the potential benefit from surgery for Caucasian skeletal class 3 profiles versus Chinese skeletal class 3 profiles.
- Hong Kong Orthodontists' perception for the potential benefit from surgery for Caucasian skeletal class 3 profiles versus maxillofacial surgeons' perception for the benefit from surgery for Caucasian skeletal class 3 profiles.
- Hong Kong Orthodontists' perception for the potential benefit from surgery for Chinese skeletal class 3 profiles versus maxillofacial surgeons' perception for the benefit from surgery for Chinese skeletal class 3 profiles.

- Perception of clinicians from the United Kingdom compared to clinicians from Hong Kong for the potential benefit from orthognathic surgery in patients with class 3 skeletal patterns

5. Quality assurance and data handling

5.1 Ethical Implications

The involved the use of profile photographs of 16 patients which were combined to form 4 individual composite images before being manipulated for inclusion in the questionnaire. The photographs were selected from the records of patients who underwent orthodontic treatment at The Royal Liverpool University Dental Hospital and consented for their images to be used for research purposes. Identifiable patient photographs were not distributed in the questionnaire.

The respondents' personal information was not known by the investigating team during this research. All data collected was anonymous with no identifiable information. The participant's personal details were kept with their respective societies; BOS, BAOMS, HKOS, HKOMFS. The cover letter sent to all clinicians, included as the first page of the questionnaire, advised respondents that they were free to decline to complete the questionnaire, (Appendices IX, X). Completion of the questionnaire was taken as consent.

5.2 Data Handling

There was no direct contact with participants during the study. All communication with participants was coordinated by the secretaries of the British Orthodontic Society (BOS), British Association of Oral and Maxillofacial Surgeons (BAOMS), Hong Kong Society of Orthodontists (HKOS) and the Hong Kong Association of Oral and Maxillofacial Surgeons (HKOMS). Questionnaire responses were anonymous. All study data has been stored and archived in line with the Medicines for Human Use Amended Regulations 2006 as defined in the Joint Clinical Trials Office Archiving SOP.

The anonymous data will be stored for 10 years. This will enable completion of the research project and also any further follow on projects to enable comparison of data. The data will be available for re-use within Liverpool Dental School Orthodontic Department and will be safeguarded data for academic use.

5.2.1 Online Data Collection

The online responses were completed in SurveyMonkey and stored by them in accordance with their secure storage policies. The anonymous data was downloaded in both Excel and SPSS format before being stored in a password protected folder on a University of Liverpool networked computer. Access permissions were held by; Jennifer Vesey, Norah Flannigan and Girvan Burnside for the purposes of analysis.

5.2.2 Paper Based Data Collection

The anonymous data was transcribed into Excel format before being stored in the same password protected folder as the online data on a University of Liverpool networked computer.

The ordinal paper responses were stored in a locked filing cabinet in the Orthodontic Department, University of Liverpool Dental Hospital.

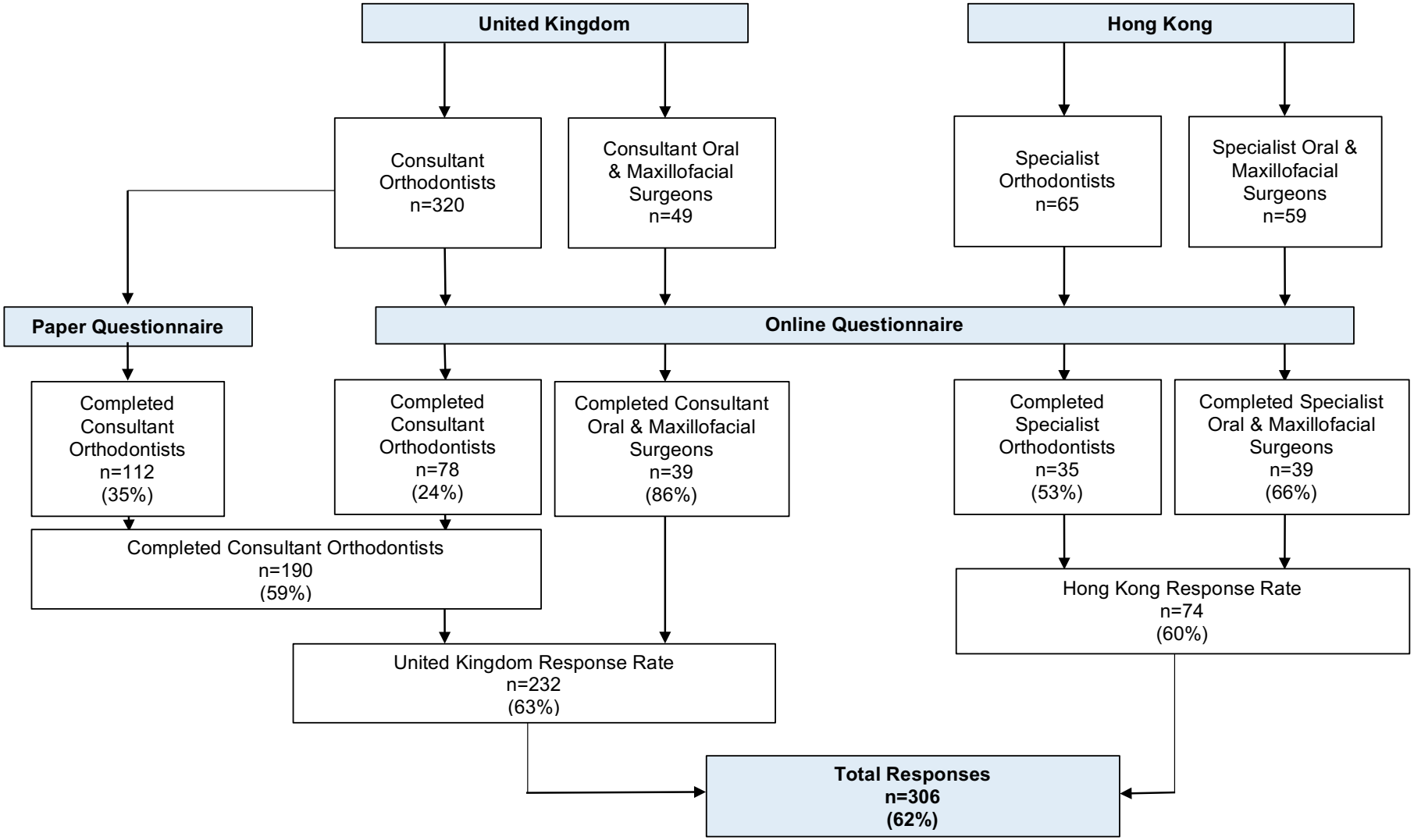


Figure 13: Flow diagram of questionnaire distribution and responses

6. Results

6.1 Response rate

The overall response rate for the was questionnaire was 62% (n=306). There were variable response rates between countries and specialities, (Table 4, Figure 13). 100% of respondents from Hong Kong completed the online questionnaire as did the oral and maxillofacial surgeons from the UK. Of the consultant orthodontists who participated in the study, a greater proportion, 59%, completed the paper questionnaire (n=112) compared with the online questionnaire, 41%, (n=78). The response rate for oral and maxillofacial surgeons was greater in both Hong Kong and the United Kingdom compared with orthodontists.

Country	Orthodontist		Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
United Kingdom	190	59%	42	86%	232	**63%**
Hong Kong	35	54%	39	66%	74	**60%**
Total	**225**	**56%**	**81**	**75.5%**	**232**	**62%**

Table 4: Overall questionnaire response rate

6.2 Intra-rater reliability

Within the questionnaire there was a duplicate profile image with the associated questions for each of the genders and ethnicities. The intra-rater reliability for the benefit of surgery was calculated from results of the original and duplicate -6mm maxillary manipulations using the methodology outlined by Landis and Koch (1977).[111] Cohen's kappa was used for the reliability of the decision for benefit of surgery as this was a binary, 'yes', 'no' response and Cohen's weighted kappa for the reliability of the attractiveness measurements due to the directional Likert scale. The kappa value was weighted using the descriptive scale originally described by Landis and Koch (1977), Table 5. [111]

Kappa Statistic	Strength of agreement
< 0.2	Poor
> 0.2 ≤ 0.4	Fair
> 0.4 ≤ 0.6	Moderate
> 0.6 ≤ 0.8	Good
> 0.8 ≤ 1	Very good

Table 5: Table of measures of agreement (Landis and Koch, 1977)

6.2.1 Benefit from Surgery

The intra-rater reliability for the benefit from surgery responses was κ0.72 SE 0.03 (95% CI 0.66; 0.78) which represents good agreement, (Table 6). When looking at the reliability of the responses for the individual profiles, the highest level of agreement was found for the Caucasian male images (κ0.69, 95% CI 0.61; 0.78) and the lowest for Chinese male images (κ0.48, 95% CI 0.28; 0.70), (Table 7). The agreement for the Chinese male images was only moderate when using the Landis and Koch (1977) interpretation of strength. The level of agreement was good for orthodontists κ0.76 SE 0.03 (95% CI 0.70; 0.82), however only moderate for oral and maxillofacial surgeons, κ0.51 SE 0.05 (95% CI 0.33; 0.68), (Table 6). The respondents from the United Kingdom had better reliability than those from Hong Kong, for the Chinese images in particular, (Table 7).

	All participants	Orthodontists	OMFS
Surgery	0.72 SE 0.03 (95% CI 0.66; 0.78)	0.76 SE 0.03 (95% CI 0.70; 0.82)	0.51 SE 0.05 (95% CI 0.33; 0.68)
Attractiveness	0.71 SE 0.02 (95% CI 0.67; 0.74)	0.70 SE 0.02 (95% CI 0.66; 0.73)	0.73 SE 0.03 (95% CI 0.67; 0.79)

Table 6: Intra-rater reliability for the questionnaire responses

6.2.2 Attractiveness Rating

As with the benefit from surgery responses there was good intra-rater reliability for the attractiveness ratings κ_w0.71 SE 0.02 (95% CI 0.67; 0.74), (Table 6). Overall the agreement was good for the images of all genders and ethnicities except for the Chinese male profiles, for which there was moderate agreement (κw 0.47, 95% CI 0.04; 0.91), (Table 7). There were similar levels of agreement between orthodontists κw 0.70 SE 0.02 (95% CI 0.66; 0.73) and oral and maxillofacial surgeons κw 0.73 SE0.03 (95% CI 0.67; 0.79). There was much better agreement between the respondents from the UK compared with those from Hong Kong. The greatest level of disagreement was for the Chinese male profiles, (Table 7).

	Caucasian Male	Caucasian Female	Chinese Male	Chinese Female
All participants				
Surgery	0.69 (95% CI 0.61; 0.78)	0.49 (95% CI 0.07; 0.92)	0.48 (95% CI 0.28; 0.70)	0.60 (95% CI 0.37; 0.83)
Attractiveness	0.65 (95% CI 0.58;0.73)	0.65 (95% CI 0.58;0.73)	0.41 (95% CI 0.32; 0.49)	0.69 (95% CI 0.62; 0.75)
Hong Kong Participants				
Surgery	0.69 (95% CI 0.52; 0.87)	0.0*	0.47 (95% CI 0.04; 0.91)	0.39 (95% CI -0.15; 0.92)
Attractiveness	0.59 (95% CI 0.42; 0.76)	0.59 (95% CI 0.43; 0.75)	0.28 (95% CI 0.92; 0.46)	0.59 (95% CI 0.44; 0.73)
UK Participants				
Surgery	0.69 (95% CI 0.60; 0.79)	0.66 (95% CI 0.23; 1)	0.49 (95% CI 0.25; 0.73)	0.65 (95% CI 0.41; 0.89)
Attractiveness	0.67 (95% CI 0.05; 0.43)	0.67 (95% CI 0.60; 0.75)	0.66 (95% CI 0.58; 0.75)	0.71 (95% CI 0.64; 0.79)

* observed agreement = 97.26%

Table 7: Kappa for the duplicate values; all participants, HK participants and UK participants

6.3 Demographics of Respondents

The demographics of the respondents were assessed as a whole and then for the UK and Hong Kong respondents separately. Differences between clinician type and also type of questionnaire completion were also looked at.

6.3.1 All respondents

When the demographics of all respondents were assessed there were significant differences for almost all of the variables between clinician type; orthodontists and oral and maxillofacial surgeons. The oral and maxillofacial surgeons were on average younger than the orthodontists and significantly more likely to be male. Orthodontists had been qualified for longer and treated a greater number of cases per year.

		Orthodontist	OMFS	Significance
Mean age (years)		47.09 (SD 9.07)	44.04 (SD12.19)	p=0.042 (CI 0.12; 6.00)
Gender	**Male**	117	64	p=<0.001 (CI -0.38; 0.16)
	Female	108	17	
How many years have you been a consultant? / How many years have you been a specialist?		12.63 (SD 8.96)	9.33 (SD 9.21)	p=0.006 (CI 0.97; 5.65)
Most frequent number of cases treated per year (%)		>30 (25.3%)	>30 (22.2%)	
Location				p=<0.001 (CI -7.24; -3.43)
Ethnicity				p=0.01 (CI -1.03; 0.39)

Table 8: Whole population demographics and comparative statistics based on speciality.

6.3.2 United Kingdom Respondents

	Orthodontist	OMFS
Mean age (years)	47.97 (SD 8.85)	49.52 (SD 9.52)
Gender		
Male	95	38
Female	95	4
How many years have you been a consultant?	13.37 (SD 8.71)	10.798 (SD 8.45)
Mean number of cases treated per year	16 - 20 4.71 (SD 1.86)	16 - 20 4.38 (SD 2.14)
Location		
Other	1	1
Eastern	7	3
London	34	2
Mersey	8	4
North West	13	3
Northern	9	2
Oxford Group	5	1
Scotland	20	0
South East	15	2
South West	14	3
South West Thames	2	-
Trent	14	1
Wales	4	1
Wessex	7	-
West Midlands	13	5
Yorkshire	16	14
Northern Ireland	8	-
Ethnicity		
White British	145	29
White Irish	11	1
Asian Chinese	2	2
Asian Indian	16	4
Asian Pakistani	2	1
Asian Bangladeshi	0	1
Other	14	4

Table 9: Comparisons of demographics of orthodontists and oral and maxillofacial surgeon respondents from the UK

For the United Kingdom respondents, the only variables for which there was a significant difference between the specialities were the location of practice and ethnicity, (Table 9). There were no statistically significant differences in demographics between the consultant orthodontists that completed the online questionnaire in comparison with those who completed the paper questionnaire, (Table 10).

	Online	Paper
Mean age (years)	47.95 (SD 9.63)	47.84 (SD 8.18)
Gender		
Male	40	55
Female	38	57
How many years have you been a consultant?	13.49 (SD 9.57)	13.29 (SD 8.08)
Mean number of cases treated per year	21 - 25 5.15 (SD 1.82)	16 - 20 4.39 (SD 21.83)
Location		
Other	1	0
Eastern	2	5
London	11	23
Mersey	7	1
North West	8	5
Northern	3	6
Oxford Group	0	5
Scotland	9	11
South East	4	11
South West	7	7
South West Thames	1	1
Trent	6	8
Wales	1	3
Wessex	3	4
West Midlands	4	9
Yorkshire	6	10
Northern Ireland	5	3
Ethnicity		
White British	64	81
White Irish	4	7
Asian Chinese	0	2
Asian Indian	7	9
Asian Pakistani	0	2
Other	3	11

Table 10: Comparisons of demographics of respondents of the paper and online questionnaire

6.3.3 Hong Kong Respondents

	Orthodontist	OMFS
Mean age (years)	42.31 (SD 8.90)	38.13 (SD 12.08)
Gender		
Male	22	26
Female	13	13
How many years have you been a specialist?	8.63 (SD 9.37)	7.74 (SD 9.82)
Mean number of cases treated per year	6 - 10 2.83 (SD 1.99)	11 - 15 3.15 (SD 2.16)
Location		
Central and Western	22	16
Eastern	-	3
Islands	1	1
Kowloon City	1	1
Kwai Tsing	-	3
Kwun Tong	1	4
North	-	2
Sha Tin	-	2
Southern	-	1
Tsuen Wan	1	-
Wan Chai	-	1
Yau Tsim Mong	9	5
Ethnicity		
Asian Chinese	33	39
Other	2	0

Table 11: Comparisons of demographics of respondents from Hong Kong

The only demographic for which there was a statistically significant difference for the Hong Kong respondents was ethnicity (p=0.002). Although statistically significant, the true difference was small. Two orthodontists described their ethnicity as ‘Eurasian’ compared to all other respondents who selected ‘Asian Chinese’.

6.3.4 Age and gender distribution of all respondents

The mean age of all respondents was 46.48 years old (SD 10.06), (Figure 14). The mean age for orthodontists was 47.09 years old (SD 9.07) and 44.03 years old (SD 12.19) for oral and maxillofacial surgeons. There was a significant difference in mean age between orthodontists and oral and maxillofacial surgeons, (p=<0.001), (Table 8). There was no significant different in age between respondents from the UK compared with respondents from Hong Kong, (p=0.062).

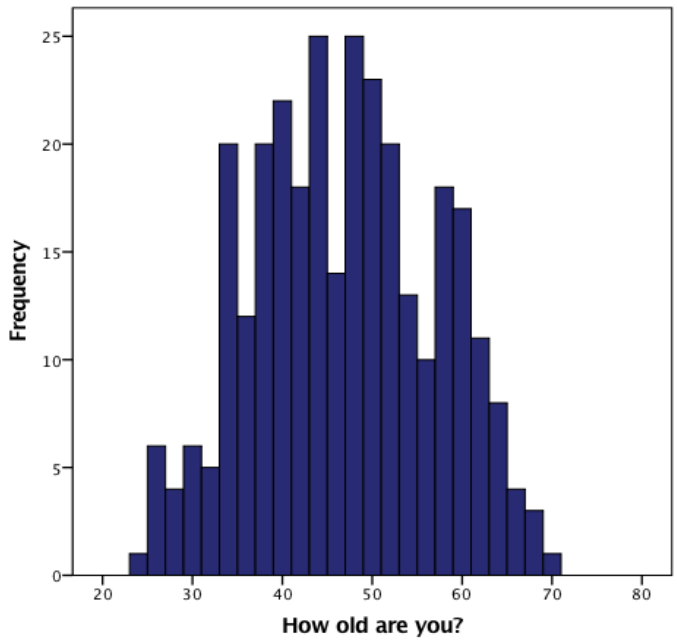


Figure 14: Age distribution of all respondents

For all respondents there was an overall male majority (59.2%). There was an almost equal distribution of males and females for orthodontists with 48% and 52% of respondents from each gender group respectively. There was a larger male majority for oral and maxillofacial surgeons (79%), (Table 12). The male majority was most pronounced for oral and maxillofacial surgeons from the United Kingdom, (Table 10).

Gender	Orthodontist		Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
Female	108	48%	17	21%	125	40.8%
Male	117	52%	64	79%	181	59.2%
Total	**225**	**100%**	**81**	**100%**	**232**	**100%**

Table 12: The gender distribution of respondents in the whole population

6.3.4.1 Age and gender for UK respondents

Overall the mean age of respondents from the UK was 48.25 years (SD 8.971), (Figure 15). The mean age of consultant orthodontists was 47.97 years old (SD 8.848) with equal proportions of male and female respondents, (Table 13). The mean age of consultant oral and maxillofacial surgeons 49.52 years old (SD 9.516) with a large male majority (91.5%), (Table 13). There was no significant difference between specialties for age, p=0.717 (CI -4.56; 1.46), or gender p=0.506, (CI -0.26; 0.19), (Table 13).

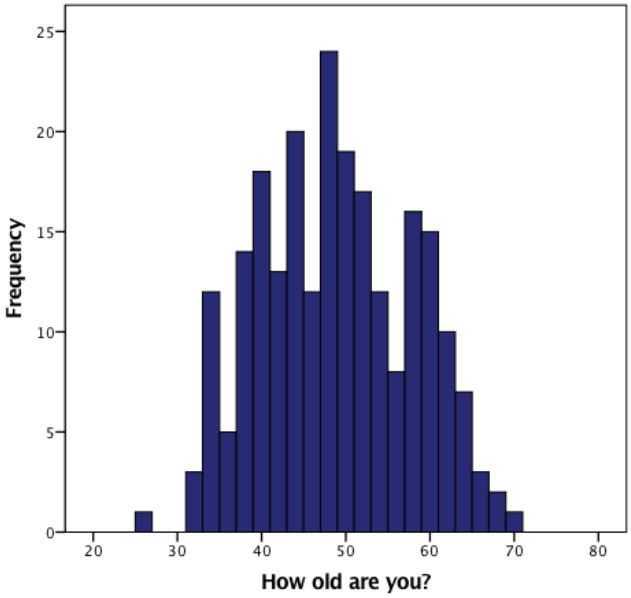


Figure 15: Histogram of the ages of respondents from the United Kingdom

Gender	Consultant Orthodontist		Consultant Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
Female	95	50%	4	9.5%	99	42.7%
Male	95	50%	38	91.5%	133	57.3%
Total	**190**	**100%**	**42**	**100%**	**232**	**100%**

Table 13: The gender distribution of respondents in the United Kingdom

6.3.4.2 Age and gender for Hong Kong respondents

The overall mean age of all clinicians from Hong Kong was 40.11 years (SD 10.827), (Figure 16). The mean age of orthodontists was 42.31 years (SD 8.897) and oral and maxillofacial surgeons 38.13 years (SD 12.08), (Table 11). There was no significant difference in age between the specialties, p=0.09 (CI -0.78; 9.15), (Table 11).

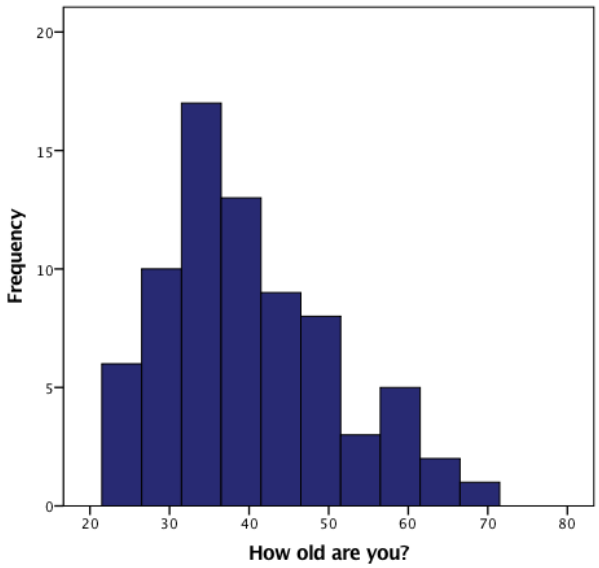


Figure 16: Mean ages of specialists from Hong Kong

The mean age of the specialist orthodontists was 44.48 years (SD 8.127) and the mean age of specialist oral and maxillofacial surgeons was 46.75 years (SD 10.862). The mean age of trainee orthodontists was 31.83 years old (SD 3.061) and the mean age of trainee oral and maxillofacial surgeons was 29.05 years old (SD 3.719). Inclusion of trainee clinicians reduced the average age of clinicians from Hong Kong.

Overall two thirds (64.9%) of respondents were male and one third (35.1%) were female. The proportions of male to female respondents were the same for both specialist orthodontists and specialist oral and maxillofacial surgeons, with one third being female (33.3%) and two thirds male (66.7%), (Table 14). These differences were not significant p=0.506 (CI -0.26; 0.19), (Table 11).

Gender	Specialist Orthodontist		Specialist Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
Female	13	33.3%	13	33.3%	26	35.1%
Male	22	66.7%	26	66.7%	48	64.9%
Total	**35**	**100%**	**39**	**100%**	**74**	**100%**

Table 14: The gender distribution of respondents from Hong Kong

6.3.5 Ethnicity for all respondents

For all respondents the most frequent ethnicity was White British (59.9%) followed by Asian Chinese (24.8%) and Asian Indian and other (6.5%), (Table 15, Figure 17). The majority of orthodontists were White British (64.4%) followed by Asian Chinese (15.6%) whereas the majority of oral and maxillofacial surgeons were Asian Chinese (50.6%) followed by White British (35.8%), (Figure 18).

Ethnicity	Orthodontist		Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
White British	145	64.4%	29	35.8%	174	56.9%
White Irish	11	4.9%	1	1.2%	12	3.9%
Asian Chinese	35	15.6%	41	50.6%	76	24.8%
Asian Indian	16	7.1%	4	4.9%	20	6.5%
Asian Pakistani	2	0.9%	1	1.2%	3	1.0%
Asian Bangladeshi	-	-	1	1.2%	1	0.3%
Other	16	7.1%	4	4.9%	20	6.5%
Total	**225**	**100%**	**81**	**100%**	**306**	**100%**

Table 15: The ethnicities of respondents in the whole population

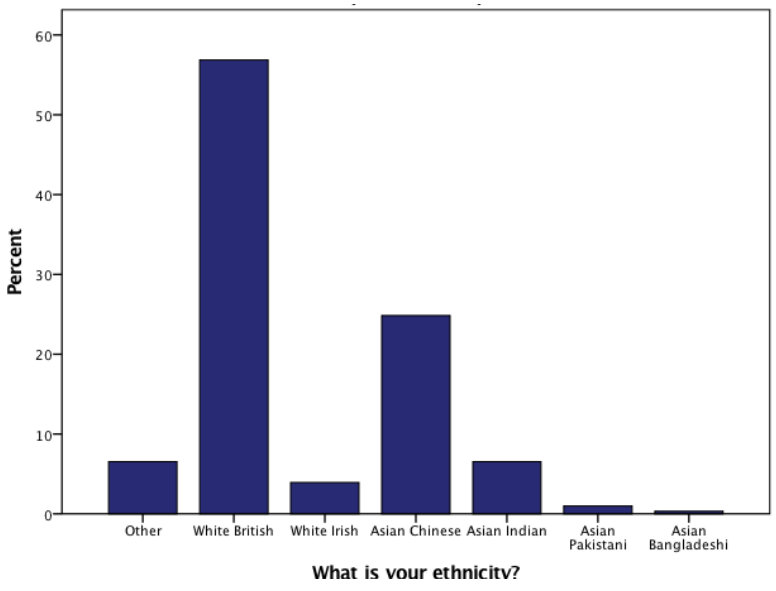
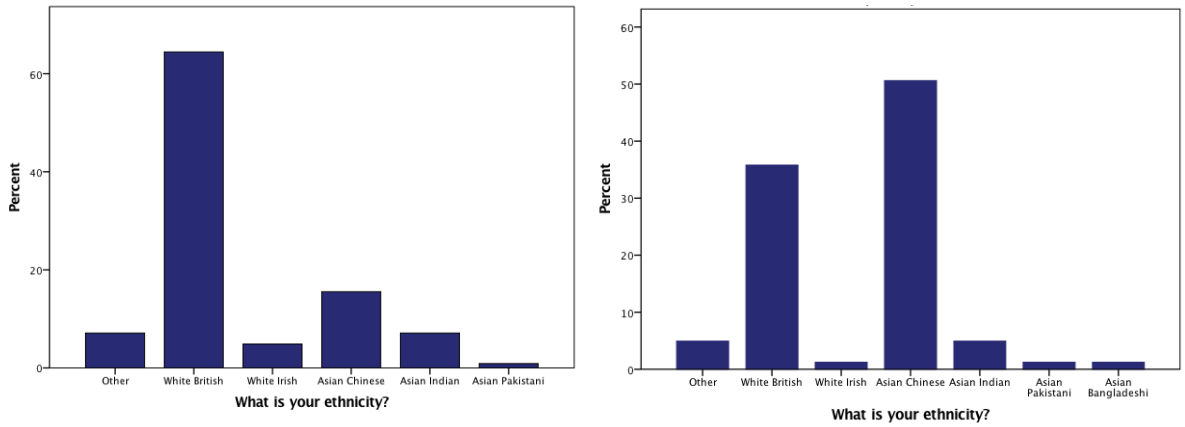


Figure 17: The ethnicities of respondents in the whole population



(A) **(B)**

Figure 18: Ethnicity of respondents in the whole population (UK & HK) by speciality; (A) Orthodontists, (B) Oral and Maxillofacial Surgeons

What is your ethnicity?		
Whole Sample	**Frequency**	**Percent**
White British	174	56.9%
White Irish	12	3.9%
Asian Chinese	76	24.8%
Asian Indian	20	6.5%
Asian Pakistani	3	1.0%
Asian Bangladeshi	1	0.3%
Other	20	6.5%
Total	**306**	**100%**
UK	**Frequency**	**Percent**
White British	174	75.0%
White Irish	12	5.2%
Asian Chinese	4	1.7%
Asian Indian	20	8.6%
Asian Pakistani	3	1.3%
Asian Bangladeshi	1	0.4%
Other	18	7.8%
Total	**232**	**100%**
HK	**Frequency**	**Percent**
Asian Chinese	72	97.5%
Other	2	2.7%
Total	**74**	**100%**

Table 16: Ethnicities of respondents from the UK and Hong Kong

There was a distinct difference in the ethnicities of respondents between the UK and HK with the majority of respondents from the UK being of Caucasian (White British/White Irish) ethnicity and the majority of respondents from Hong Kong being of Asian Chinese ethnicity, (Table 16).

The majority of respondents from Hong Kong were Asian Chinese (97.5%), with two respondents of mixed Chinese Asian/Eurasian ethnicity (2.7%).

6.3.5.1 Ethnicity for UK respondents only

For all respondents the most frequent ethnicity was White British (75%) followed by Asian Indian (8.6%) and other (7.8%), (Table 17). 1.7% of respondents reported an Asian Chinese background; 1.05% of consultant orthodontists and 2.76% of consultant oral and maxillofacial surgeons. The distribution pattern of ethnicities was the same for both consultant orthodontists and consultant oral and maxillofacial surgeons with some minor differences in the overall percentages, (Figure 19).

UK	Consultant Orthodontist		Consultant Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
White British	145	76.3%	29	69.05%	174	75.0%
White Irish	11	5.79%	1	2.38%	12	5.2%
Asian Chinese	2	1.05%	2	2.76%	4	1.7%
Asian Indian	16	8.42%	4	9.52%	20	8.6%
Asian Pakistani	2	1.05%	1	2.38%	3	1.3%
Asian Bangladeshi	0	0%	1	2.38%	1	0.4%
Other	14	7.37%	4	9.52%	18	7.8%
Total	**190**	**100%**	**42**	**100%**	**232**	**100%**

Table 17: The ethnicities of respondents in the United Kingdom

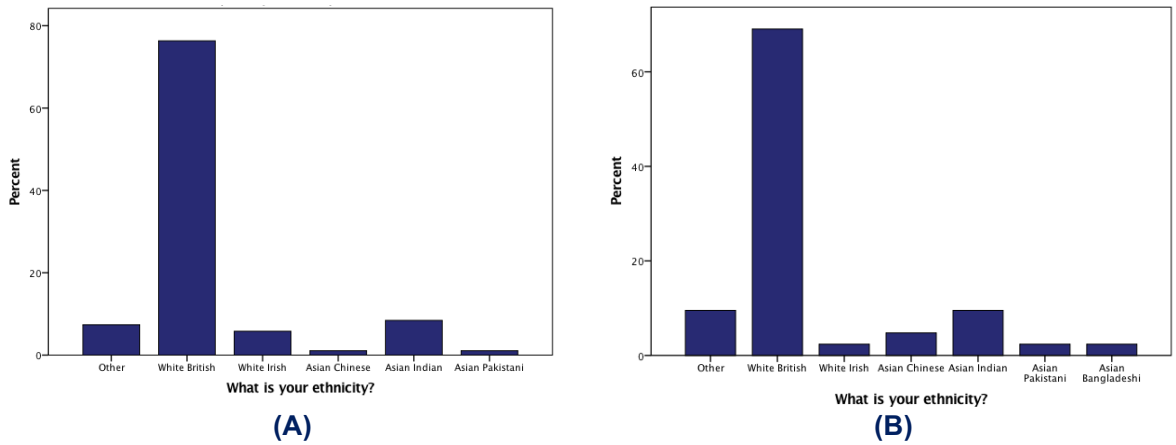


Figure 19: Ethnicity of respondents in the UK by speciality; (A) Consultant Orthodontists, (B) Consultant Oral and Maxillofacial Surgeons

Of the 18 respondents that selected 'other' as their ethnicity, 12 specified this; (Table 18);

	Total Number
Mixed	2
Iranian	2
White Greek	2
Sri-Lankan Asian	2
British Asian	1
British Indian	1
White	1
Australian	1
Total	**12**

Table 18: Specified ethnicities of those who selected 'other'

6.3.5.2 Ethnicity for Hong Kong respondents only

The majority, 97.3%, of clinicians from Hong Kong were Asian Chinese with 2.7% describing themselves as Eurasian (mixed Asian Chinese/Caucasian). 100% of specialist oral and maxillofacial surgeons and 94.3% of specialist orthodontists were Asian Chinese, (Table 19). These differences were not statistically significant p=0.002, (CI -0.397; 0.054).

UK	Specialist Orthodontist		Specialist Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
Asian Chinese	33	94.3%	39	100%	72	97.3%
Other	2	5.7%	0	0%	2	2.7%
Total	**35**	**100%**	**39**	**100%**		**100%**

Table 19: The ethnicities of respondents from Hong Kong

6.3.5.3 Region of practice for UK respondents

Respondents were from all regions of the United Kingdom with variable distribution. The greatest proportion of respondents were from London (15.5%) followed by Yorkshire (12.9%) and Scotland (8.6%), (Figure 20). The areas with fewest respondents were South West Thames (0.9%), Wales (2.2%) and Oxford (2.6%). There was no statistical difference between the region of practice for consultant orthodontists and consultant oral and maxillofacial surgeons, p=0.016, (CI -3.25; 0.06), (Table 20).

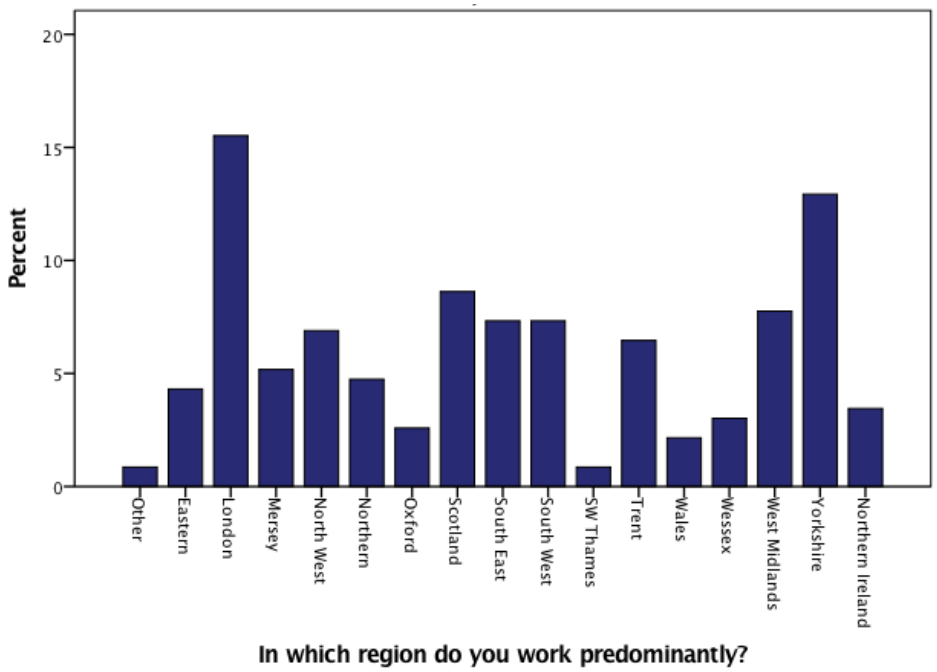


Figure 20: Region of practice for respondents (regions based on the BOS audit groups)

In which region do you work predominantly?			
	Frequency	Percent	Valid Percent
Eastern	10	4.3	4.3
London	36	15.5	15.5
Mersey	12	5.2	5.2
North West	16	6.9	6.9
Northern	11	4.7	4.7
Northern Ireland	8	3.4	3.4
Other (please specify)	2	.9	.9
Oxford Group	6	2.6	2.6
Scotland	20	8.6	8.6
South East	17	7.3	7.3
South West	17	7.3	7.3
South West Thames	2	.9	.9
Trent	15	6.5	6.5
Wales	5	2.2	2.2
Wessex	7	3.0	3.0
West Midlands	18	7.8	7.8
Yorkshire	30	12.9	12.9
Total	**232**	**100.0**	**100.0**

Table 20: The location of respondents in the United Kingdom

6.3.5.4 Region of practice for HK respondents

Respondents were from almost all regions of Hong Kong with variable spread. The greatest proportion of respondents were from Central and Western (51.4%) followed by Yau Tsim Mong (18.9%) and Kwun Tong (6.8%), (Figure 21). There was no statistical difference between the location of specialist orthodontists and specialist oral and maxillofacial surgeons, p=0.629 (CI -0.31; 0.95), (Table 21).

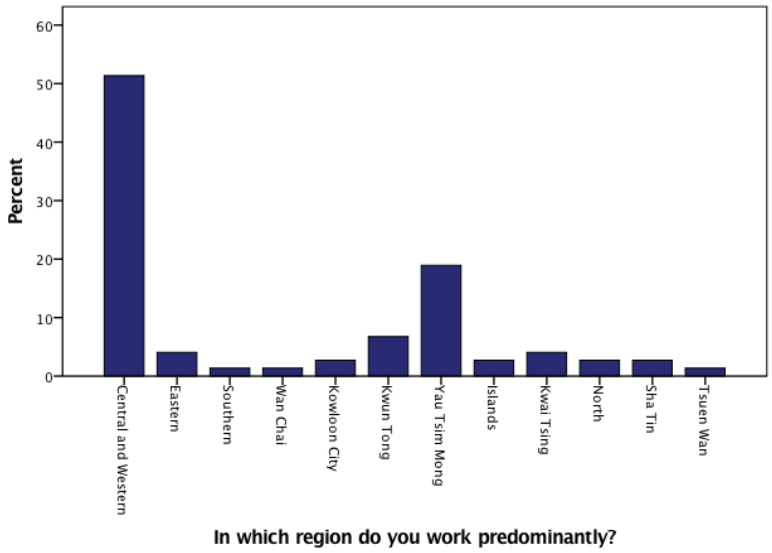


Figure 21: The location of respondents in Hong Kong

In which region do you work predominantly?		
	Frequency	Percent %
Central and Western	38	51.4%
Eastern	3	4.1%
Islands	2	2.7%
Kowloon City	2	2.7%
Kwai Tsing	3	4.1%
Kwun Tong	5	6.8%
North	2	2.7%
Sha Tin	2	2.7%
Southern	1	1.4%
Tsuen Wan	1	1.4%
Wan Chai	1	1.4%
Yau Tsim Mong	14	18.9%
Total	**74**	**100%**

Table 21: The location of respondents in Hong Kong

6.3.6 Length of time as a specialist for all respondents

The mean number of years spent as a specialist for the whole population was 11.76 years (SD 9.13), (Figure 22). Orthodontists had spent longer on average as specialists, 12.64 years (SD 8.96) than oral and maxillofacial surgeons, 9.33 years (SD 9.21). The mean length of time since becoming a specialist was greater for orthodontists than oral and maxillofacial surgeons in both the United Kingdom and Hong Kong, (Table 22).

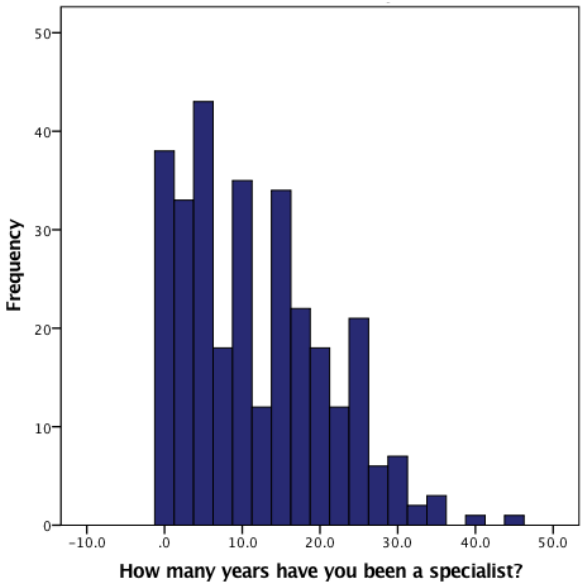


Figure 22: The distribution of years as a consultant or specialist for the whole population

	Orthodontist		Oral and Maxillofacial Surgeon		All	
	Mean	SD	Mean	SD	Mean	SD
UK	13.37	8.71	7.74	9.82	12.91	8.70
HK	8.63	9.37	10.80	8.45	8.16	9.55
All	12.64	8.96	9.33	9.21	11.76	9.13

Table 22: The mean number of years as a consultant or specialist for the whole population

6.3.6.1 Number of years since becoming a consultant for UK respondents

For the 232 respondents who completed the questionnaire the number of years since becoming a consultant ranged from 0-45 years with a mean of 12.91 years (SD 8.70), (Figure 23) The mean length of time since becoming a consultant was greater for orthodontists, 13.37 years (SD 8.71), compared with oral and maxillofacial surgeons, 7.74 years (SD 9.82), (Figure 24). However, this was not significant p=0.779, (CI -0.33; 5.49).

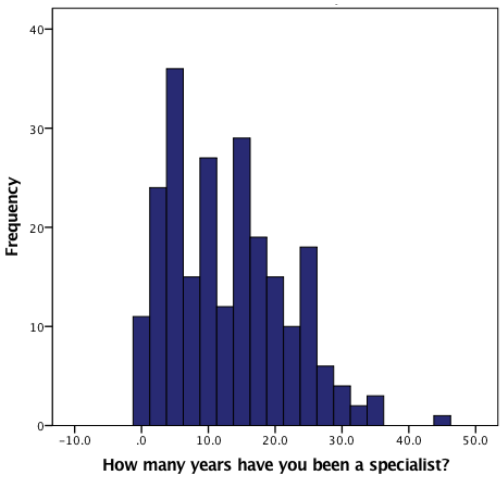
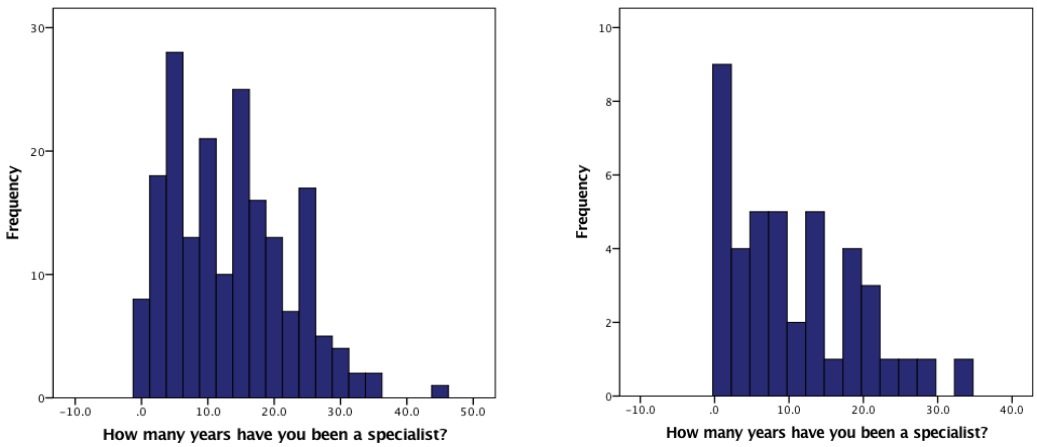


Figure 23: The distribution of years as a consultant for all UK respondents



(A) **(B)**

Figure 24: The distribution of years as a consultant for all UK respondents by speciality; (A) Orthodontists, (B) Oral and Maxillofacial Surgeons

6.3.6.2 Number of years since becoming a specialist for Hong Kong respondents

For the 74 respondents who complete the questionnaire the number of years since becoming a specialist ranged from 0-40 years, (Figure 25), with a mean of 8.16 years (SD 9.55). The mean length of time since becoming a specialist was greater for orthodontists, 8.63 years (SD 9.37) compared with oral and maxillofacial surgeons 7.74 years (SD 9.82), (Figure 26). However, this was not significant p=0.721, (CI -0.37; 5.34). A large proportion of respondents indicated 0 years as a specialist which can be accounted for by the number of trainee orthodontists and oral and maxillofacial surgeons that completed the questionnaire.

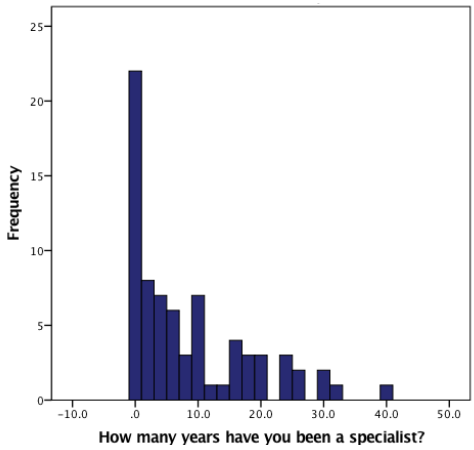
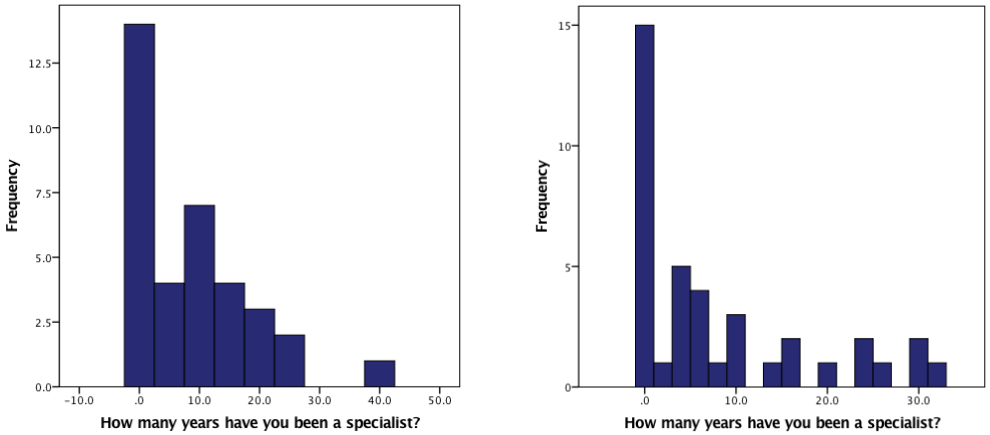


Figure 25: The distribution of years as a specialist for all HK respondents



(A) **(B)**

Figure 26: The distribution of years as a specialist for all HK respondents by speciality; (A) Orthodontists, (B) Oral and Maxillofacial Surgeons

6.3.7 Number of orthognathic cases treated per year for all respondents

The greatest proportion of clinicians reported (24.5%) reported undertaking > 30 orthognathic cases a year, (Table 23, Figure 27). The greatest number or orthodontists and oral and maxillofacial surgeons undertook > 30 cases per year, (Figure 28).

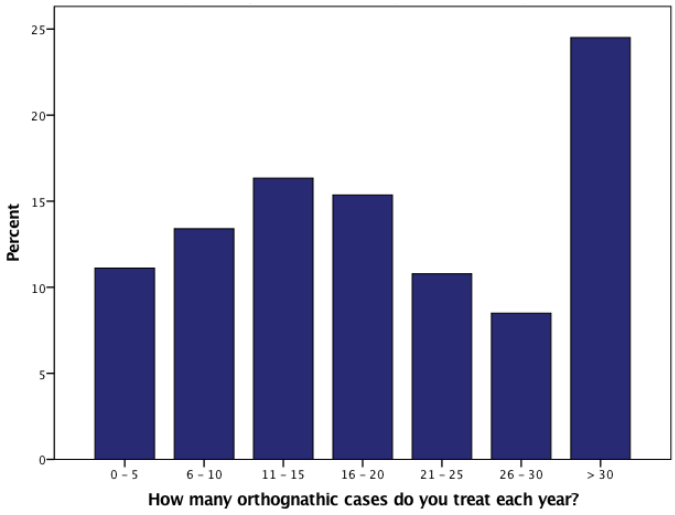
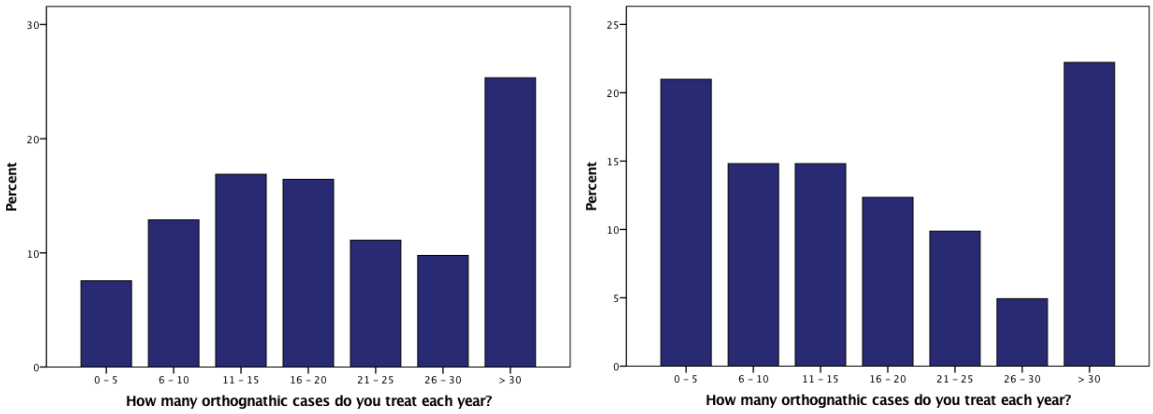


Figure 27: Number of orthognathic cases treated by clinicians per year in the whole population

Cases/Year	Orthodontist		Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
0 - 5	17	**7.6**%	17	21.0%	34	11.1%
6 - 10	29	12.9%	12	14.8%	41	13.4%
11 - 15	38	16.9%	12	14.8%	50	16.3%
16 - 20	37	16.4%	10	12.3%	47	15.4%
21 - 25	25	11.1%	8	9.9%	33	10.8%
26 - 30	22	9.8%	4	4.9%	26	8.5%
> 30	57	25.3%	18	22.2%	75	24.5%
Total	**232**	**100%**	**74**	**100%**	**306**	**100%**

Table 23: Number of Orthognathic Cases Treated Per Year in the whole population

There was a broad range of cases treated per year (0-5 to >30). The mean number of cases undertaken per year for both consultant orthodontists and consultant oral and maxillofacial surgeons was 16 - 20. There was no statistically significant difference in the number of cases treated annually between consultant orthodontists and consultant oral and maxillofacial surgeons p=0.268 (CI -0.32; 0.97), Table 8.



(A) **(B)**

Figure 28: Number of orthognathic cases treated per year in the whole population (UK & HK); (A) Orthodontists, (B) Oral and Maxillofacial Surgeons

6.3.7.1 Number of orthognathic cases treated in the UK each year

The greatest proportion of clinicians reported (27.2%) reported undertaking > 30 orthognathic cases a year, (Table 24, Figure 29). This was the case for both consultant orthodontists and consultant oral and maxillofacial surgeons.

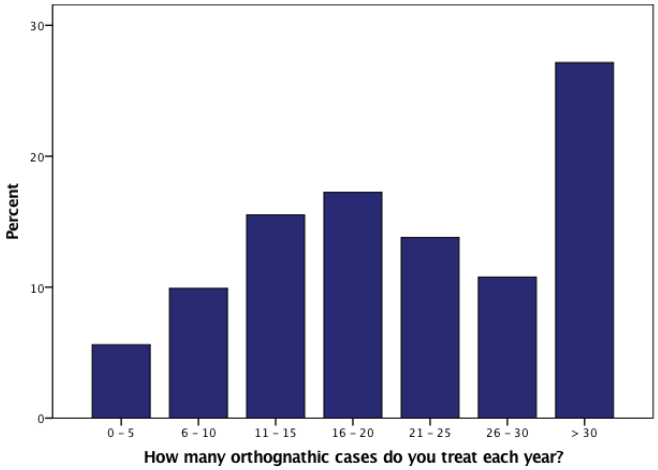
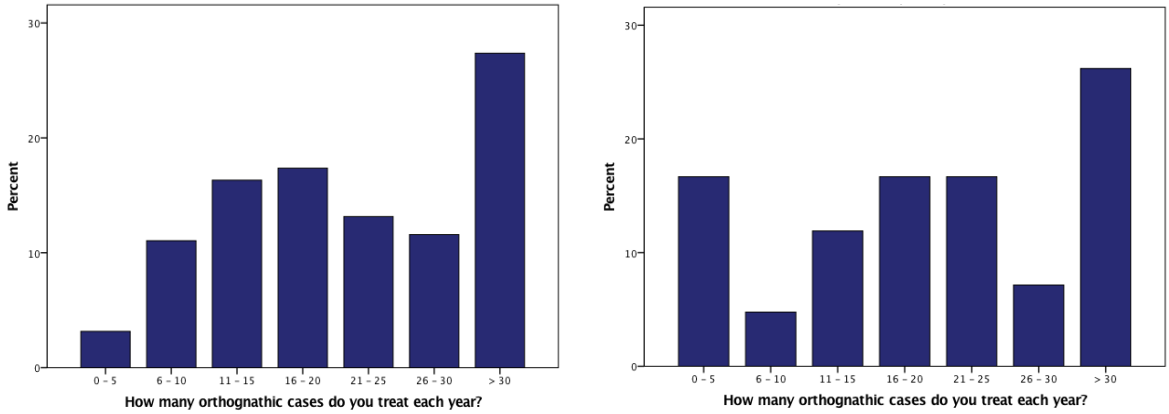


Figure 29: Number of orthognathic cases treated by clinicians per year in the United Kingdom

Cases/Year	Consultant Orthodontist		Consultant Oral and Maxillofacial Surgeon		Total Number	Total %
	Number	%	Number	%		
0 - 5	6	3.2%	7	16.7%	13	5.6%
6 - 10	21	11.1%	2	4.8%	23	9.9%
11 - 15	31	16.3%	5	11.9%	36	15.5%
16 - 20	33	17.4%	7	16.7%	40	17.2%
21 - 25	25	13.2%	7	16.7%	32	13.8%
26 - 30	22	11.6%	3	71%	25	10.8%
> 30	52	27.4%	11	26.2%	63	27.2%
Total	**190**	**100%**	**42**	**100%**	**232**	**100%**

Table 24: Number of Orthognathic Cases Treated Per Year in the United Kingdom

There was a broad range of number of cases treated per year (0-5 to >30). The mean number of cases undertaken per year for both consultant orthodontists and consultant oral and maxillofacial surgeons was 16-20. There was no statistically significant difference in the number of cases treated annually between consultant orthodontists and consultant oral and maxillofacial surgeons p=0.268 (CI -0.32; 0.97), (Table 9).



(A) **(B)**

Figure 30: Number of orthognathic cases treated per year in the United Kingdom; (A) Consultant Orthodontists, (B) Consultant Oral and Maxillofacial Surgeons

6.3.7.2 Number of orthognathic cases treated in the Hong Kong each year

The greatest proportion of clinicians reported (28.4%) reported undertaking 0-5 orthognathic cases a year, (Figure 31). This was the case for both specialist orthodontists (31.4%) and specialist oral and maxillofacial surgeons (25.6%); an equal proportion (25.6%) of specialist oral and maxillofacial surgeons also treat 6-10 cases/year. The high frequency of 0-5 cases/year may have been influenced by responses from trainee orthodontists and oral and maxillofacial surgeons who undertake fewer cases per year.

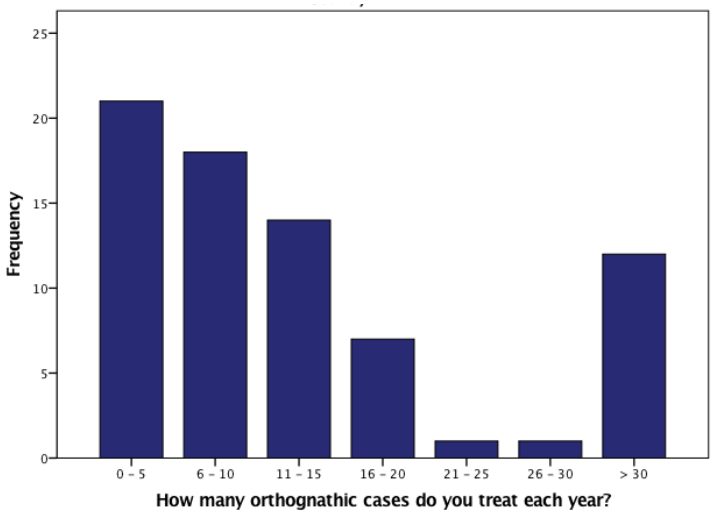


Figure 31: Number of orthognathic cases treated per year (Hong Kong)

	Specialist Orthodontist		Specialist Oral and Maxillofacial Surgeon		Total Number	Total %
Cases/Year	Number	%	Number	%		
0 - 5	11	31.4%	10	25.6%	21	28.4%
6 - 10	8	22.9%	10	25.6%	18	24.3%
11 - 15	7	20.0%	7	17.9%	14	18.9%
16 - 20	4	11.4%	3	7.7%	7	9.5%
21 - 25	-	0%	1	2.6%	1	1.4%
26 - 30	-	0%	1	2.6%	1	1.4%
> 30	5	14.3%	7	17.9%	12	16.2%
Total	**33**	**100%**	**39**	**100%**	**74**	**100%**

Table 25: Number of Orthognathic Cases Treated Per Year in Hong Kong

The mean number of cases undertaken per year for specialist orthodontists was 6-10 with a range of 0-30. The number of cases treated gradually reduced from 0-20 with a slight increase again at >30 (Table 25). No specialist orthodontists reported treating between 21-30 cases per year, however 14.3% reported treating >30/year.

The mean number of cases undertaken per year for specialist oral and maxillofacial surgeons was 11-15 with a range of 0-30. 50.2% of specialist oral and maxillofacial surgeons undertook between 0-10 cases per year, decreasing to 2.6% for 20-30 cases before increasing again to 17.9% for >30.

There was no statistically significant difference in the number of cases treated annually between specialist orthodontists and specialist oral and maxillofacial surgeons, p=0.442 (CI -1.29; 0.64), (Table 11).

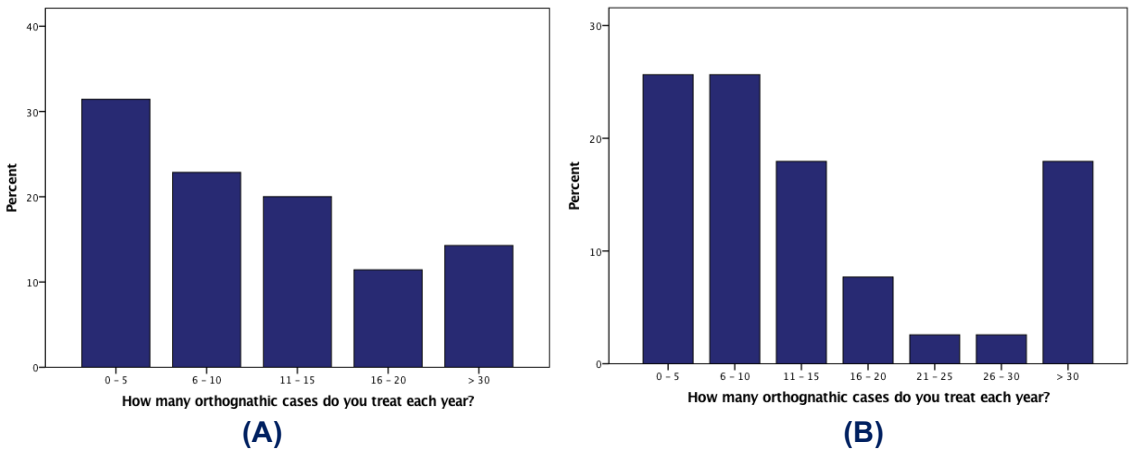


Figure 32: Number of orthognathic cases treated per year in Hong Kong SAR; (A) Consultant Orthodontists, (B) Consultant Oral and Maxillofacial Surgeons

6.3.7.3 Clinician attractiveness ratings Hong Kong

		How would you rate your own facial attractiveness?				
		Extremely important	Very important	Slightly important	Neither important nor unimportant	**Total**
Specialty	Specialist Oral and Maxillofacial Surgeon	1	7	9	3	**20**
	Specialist Orthodontist	1	14	12	2	**29**
	Trainee Oral and Maxillofacial Surgeon	0	5	12	2	**19**
	Trainee Orthodontist	0	4	2	0	**6**
Total		**2**	**30**	**35**	**7**	**74**

Table 26: Rating of importance of own facial attractiveness in Hong Kong

		How important do you think it is to have an attractive facial appearance?				
		Extremely important	Very important	Slightly important	Neither important nor unimportant	**Total**
Specialty	Specialist Oral and Maxillofacial Surgeon	1	13	6	0	**20**
	Specialist Orthodontist	3	18	7	0	**29**
	Trainee Oral and Maxillofacial Surgeon	1	12	6	1	**19**
	Trainee Orthodontist	0	6	0	0	**6**
Total		**5**	**49**	**19**	**1**	**74**

Table 27: Rating of the importance of facial attractiveness in Hong Kong

6.4 Perceived benefit from surgery

Respondents perceived potential benefit from orthognathic surgery for all manipulated class 3 profiles, (Table 28). There proportion of respondents perceiving a potential benefit from surgery for the images increased with increasing manipulation (Figure 33, Figure 34, Figure 35, Figure 36). The images rated as most likely to benefit from surgery were those with the largest manipulations (-6mm maxilla and +6mm mandible). This was true for both males and females. Surgery was more likely to be recommended in females than males, and for all levels of maxillary retrusion in comparison with mandibular prognathism.

The threshold for perceiving benefit from surgery was lower amongst the Chinese composite images in comparison to the Caucasian images. This was true for all levels of manipulation except for the -4mm maxillary image for the Chinese female which was not recommended for surgery as frequently as the Caucasian female image of the same manipulation.

Manipulation (mm)	Caucasian Male	Caucasian Female	Chinese Male	Chinese Female
0mm baseline	6.5%	2.3%	11.1%	3.9%
Mandible manipulated anteriorly from baseline:				
+2mm	3.3%	2.3%	5.2%	1.6%
+4mm	5.2%	24.8%	9.5%	33.0%
+6mm	49.3%	76.1%	61.8%	95.4%
Maxilla manipulated anteriorly from baseline				
-2mm	2%	3.3%	6.9%	2.9%
-4mm	11.1%	46.7%	42.8%	16.0%
-6mm	59.5%	98.7%	94.1%	95.1%

Table 28: Frequencies of patient being recommended for orthognathic surgery (UK and HK)

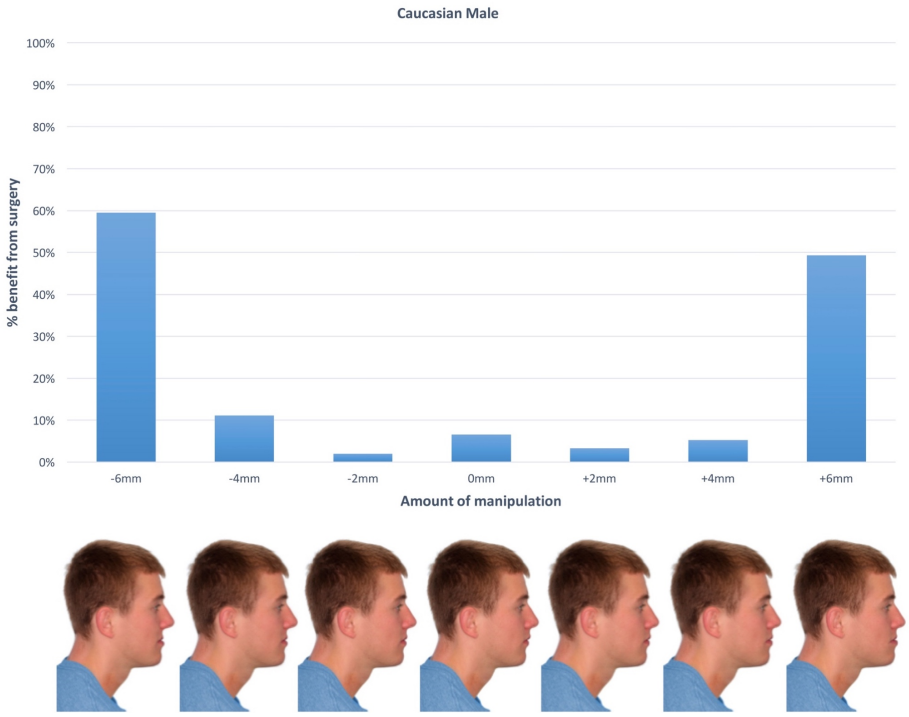


Figure 33: The proportion of responses indicating a potential benefit from surgery for the manipulated Caucasian male images

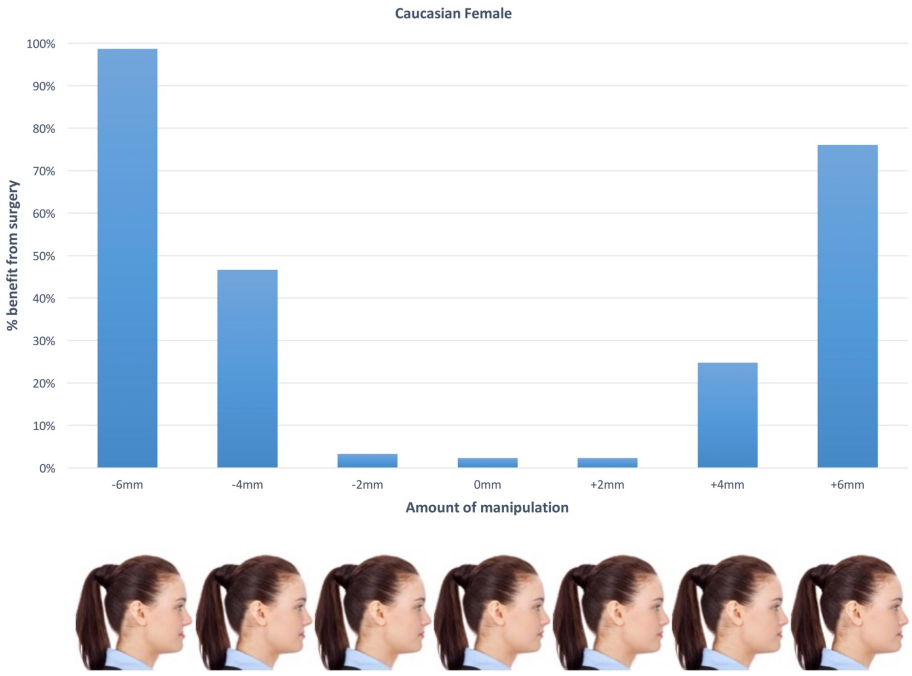


Figure 34: The proportion of responses indicating a potential benefit from surgery for the manipulated Caucasian female images

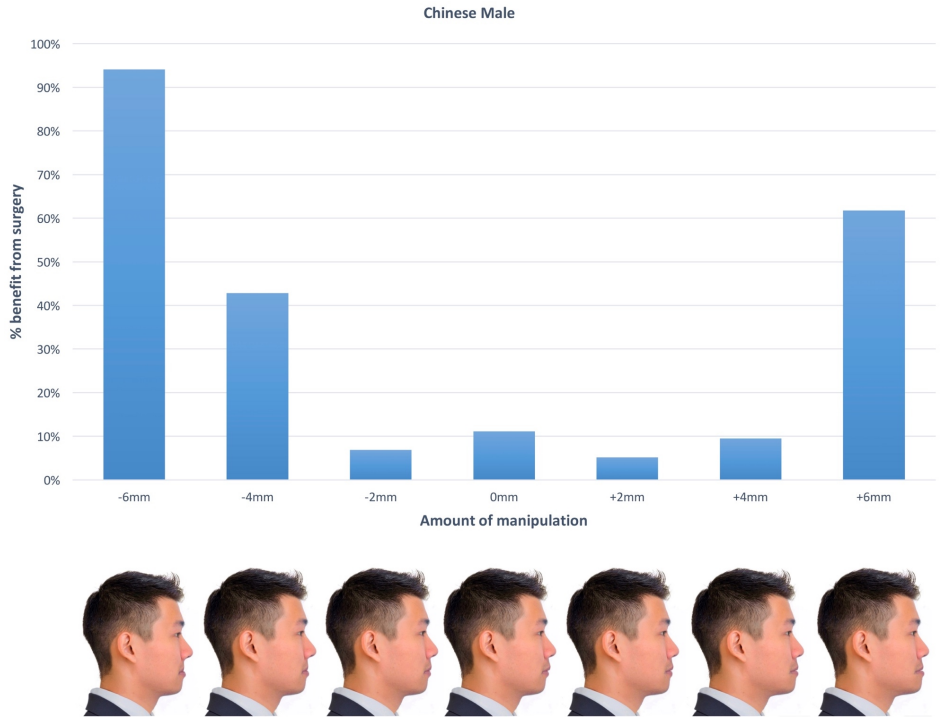


Figure 35: The proportion of responses indicating a potential benefit from surgery for the manipulated Chinese male images

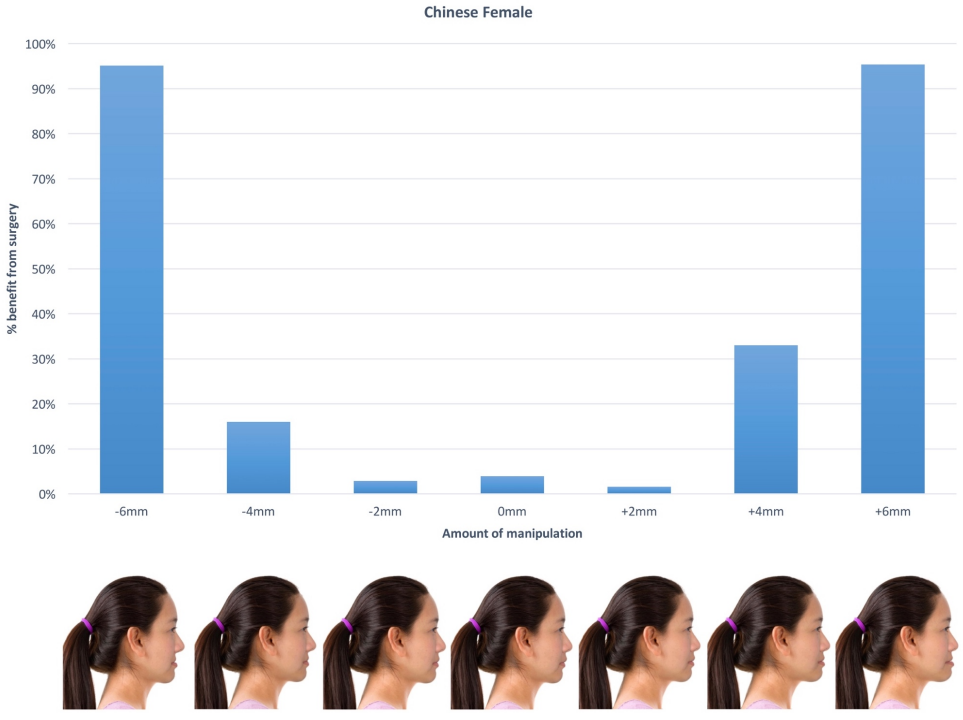


Figure 36: The proportion of responses indicating a potential benefit from surgery for the manipulated Chinese female images

The profiles which were rated as most likely to benefit from surgery for each of the genders and ethnicities were all -6mm maxillary manipulations, apart from Chinese Female which was the +6mm mandibular manipulation, (Figure 37).

However, the difference between the -6mm maxilla and +6mm mandible manipulations for the Chinese female was only 0.3%.

Figure 37: The profiles rated as most likely to benefit from surgery by all respondents for each gender and ethnicity; (a) male Caucasian, (b) female Caucasian, (c) male Chinese, (d) female Chinese

6.4.1 Benefit from surgery orthodontists and oral and maxillofacial surgeons

Orthodontists were less likely to rate the mild class 3 images as having benefit from surgery than oral and maxillofacial surgeons, (Table 29, Table 30). Surgery was recommended by oral and maxillofacial surgeons for profiles with all amounts of manipulation, including the baseline profile, (Figure 38, Figure 39, Figure 40, Figure 41). Both orthodontists and oral and maxillofacial surgeons were less likely to see potential benefit from surgery for the Caucasian male manipulations than the profiles from the other ethnicities and genders.

Manipulation (mm)	Caucasian Male	Caucasian Female	Chinese Male	Chinese Female
0mm baseline	17.3%	7.4%	25.9%	8.6%
Mandible manipulated anteriorly from baseline:				
+2mm	11.1%	6.2%	12.3%	4.9%
+4mm	11.1%	46.9%	24.7%	54.3%
+6mm	71.6%	85.2%	84.0%	98.8%
Maxilla manipulated anteriorly from baseline				
-2mm	5%	7.4%	21.0%	8.6%
-4mm	29.6%	67.9%	56.8%	27.2%
-6mm	96.3%	98.8%	93.8%	95.3%

Table 29: Frequencies of patient being recommended for orthognathic surgery by oral and maxillofacial surgeons

Manipulation (mm)	Caucasian Male	Caucasian Female	Chinese Male	Chinese Female
0mm baseline	2.7%	0.4%	5.8%	2.2%
Mandible manipulated anteriorly from baseline:				
+2mm	0.4%	0.9%	2.7%	0.4%
+4mm	3.1%	16.9%	4.0%	25.4%
+6mm	41.3%	73.2%	53.8%	94.6%
Maxilla manipulated anteriorly from baseline				
-2mm	1%	1.8%	1.8%	0.9%
-4mm	4.5%	39.3%	37.8%	12.1%
-6mm	55.3%	98.7%	94.2%	95.1%

Table 30: Frequencies of patient being recommended for orthognathic surgery by orthodontists

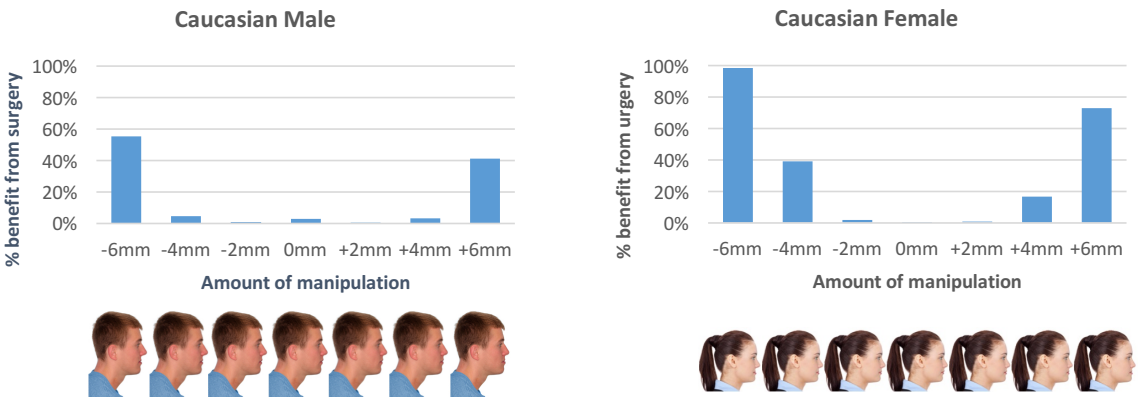


Figure 38: The proportion of responses from orthodontists indicating possible benefit from surgery Caucasian male and female images.

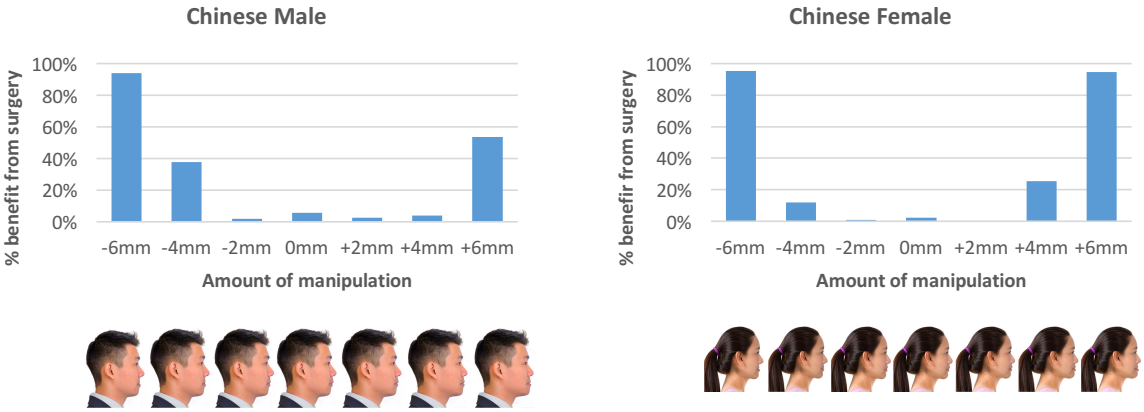


Figure 39: The proportion of responses from orthodontists indicating possible benefit from surgery Chinese male and female images

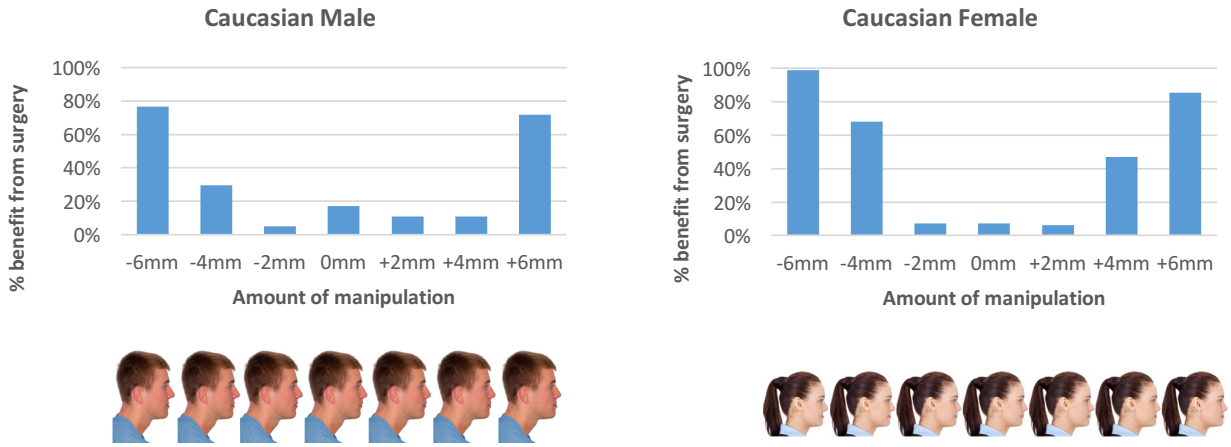


Figure 40: The proportion of responses from oral and maxillofacial surgeons indicating possible benefit from surgery Caucasian male and female images.

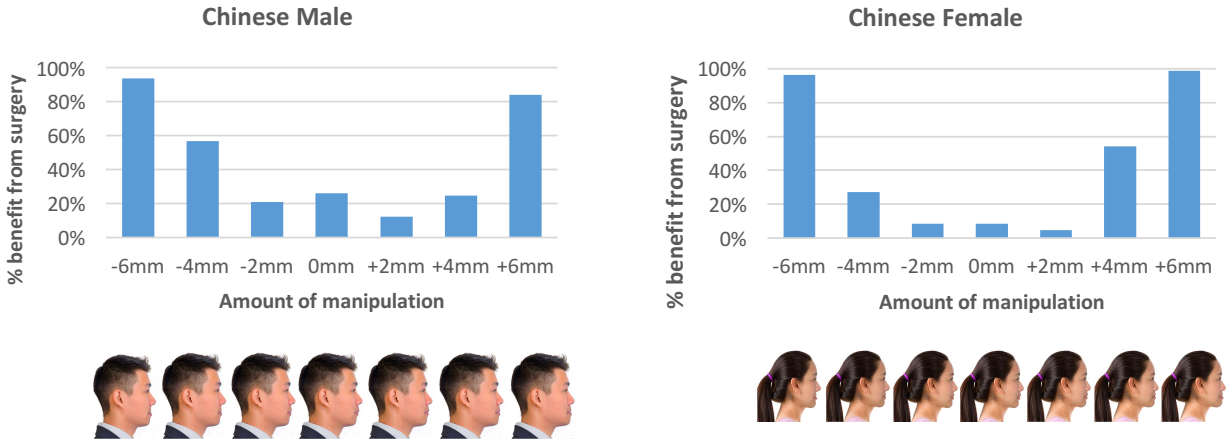


Figure 41: The proportion of responses from oral and maxillofacial surgeons indicating possible benefit from surgery for Chinese male and female images.

Variable	Odds ratio	95% confidence interval	P-value
Gender of rater (female vs male)	1.13	0.80, 1.62	0.489
Importance of attractive appearance	1.16	0.91, 1.49	0.231
Years as a consultant**	0.88	0.80, 0.97	0.007
Specialty (oral and maxillofacial surgeon vs. orthodontics)	3.94	2.62, 5.92	<0.001
Number of orthognathic patients treated per year*	1.18	1.08, 1.28	<0.001
Race of image (Chinese vs. Caucasian)	2.09	1.81, 2.43	<0.001
Gender of image (Female vs Male)	3.10	2.66, 3.61	<0.001
Manipulation (vs. none)			
Maxillary 2 mm	0.55	0.36, 0.84	0.006
Maxillary 4 mm	12.06	8.84, 16.44	<0.001
Maxillary 6 mm	556.55	388.37, 797.56	<0.001
Mandibular 2 mm	0.44	0.28, 0.69	<0.001
Mandibular 4 mm	5.09	3.71, 6.99	<0.001
Mandibular 6 mm	149.74	107.79, 208.14	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

** Coefficient refers to increase of 5 years

Table 31: Multivariate logistic regressions for benefit from surgery for the whole population

6.4.2 Multivariate logistic regression for benefit from surgery for the whole population

Multivariate analysis was used to look at the factors which affected respondent's decision as to whether they would recommend surgery for each image, (Table 31).

The variables which had a statistically significant effect on the recommending benefit from surgery for the images were; increasing number of years as a consultant, oral and maxillofacial surgeons, increasing numbers of orthognathic surgical cases treated per year, Chinese ethnicity and female gender, (Table 31).

The variable with the greatest effect on the perception of need for surgery was the occupation of the respondent with oral and maxillofacial surgery much more likely to recommend surgery compared with orthodontists, (odds ratio = 3.94; p=<0.001; 95% CI 2.62, 5.92).

There was a statistically significant perception of benefit from surgery for all manipulations compared with the baseline image, (Table 31).

The perception of benefit increased with increasing manipulation for both the maxillary and mandibular manipulations with the 6mm manipulations perceived as having the greatest benefit from surgery. The manipulation which was perceived as having the greatest benefit was the -6mm maxillary manipulation (odds ratio = 556.55; p=<0.001; 95% CI 388.37, 797.56). Although there was benefit from surgery for the 2mm manipulations this was small; maxillary -2mm (odds ratio = 0.55; p=<0.006; 95% CI 0.36, 0.84), mandibular +2mm (odds ratio = 0.44; p=<0.001; 95% CI 107.79, 208.14).

For each increment of manipulation, the perception of benefit was greatest for maxillary retrusion compared with mandibular prognathism. The perceived benefit from surgery was 1.25 greater for the -2mm maxillary manipulation, 2.37 greater for the -4mm maxillary manipulation and 3.72 greater for the -6mm maxillary manipulation compared with their corresponding mandibular manipulation.

Interpretation of the multivariate logistic regressions (Table 31), show that the odds of perceived benefit from surgery:

- Decreased by 12% for every 5-year increase in experience of consultant
- Was 292% greater for oral and maxillofacial surgeons than orthodontists
- Was 18% greater for each 5 patient increase per year in number of orthognathic patients treated
- Increased 2.09 times for Chinese images than Caucasian images
- Were 3.10 times greater for the female images compared with male images of the same amount of manipulation
- Were 1.25 times higher for the image that had 2mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible
- Were 2.37 times higher for the image that had 4mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible.
- Were 3.72 times higher for the image that had 6mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible.

6.4.4 Perceived benefit from surgery United Kingdom

The trend for recommending surgery for each of the manipulated images was similar for each of the ethnicities and genders, (Figure 42, Figure 43). However, for the UK respondents the milder class 3 profiles; -2mm maxilla and -2mm mandible, were not rated as potentially benefitting from surgery as much as clinicians from Hong Kong. The more severe class 3 profiles were all rated as most likely to benefit from surgery, however the Caucasian male images were not rated as benefitting from surgery as much as all of the other images.

Manipulation (mm)	Caucasian Male	Caucasian Female	Chinese Male	Chinese Female
0mm baseline	3.9%	0.9%	7.8%	3.0%
Mandible manipulated anteriorly from baseline:				
+2mm mandible	1.7%	1.7%	2.6%	0.9%
+4mm mandible	3.9%	20.3%	4.3%	28.9%
+6mm mandible	48.7%	75.9%	66.0%	96.1%
Maxilla manipulated anteriorly from baseline				
-2mm maxilla	1.3%	2.6%	2.6%	1.3%
-4mm maxilla	8.2%	41.4%	38.4%	12.9%
-6mm maxilla	57.3%	99.1%	94.4%	94.4%

Table 32: Frequencies of patient being recommended for orthognathic surgery (UK)

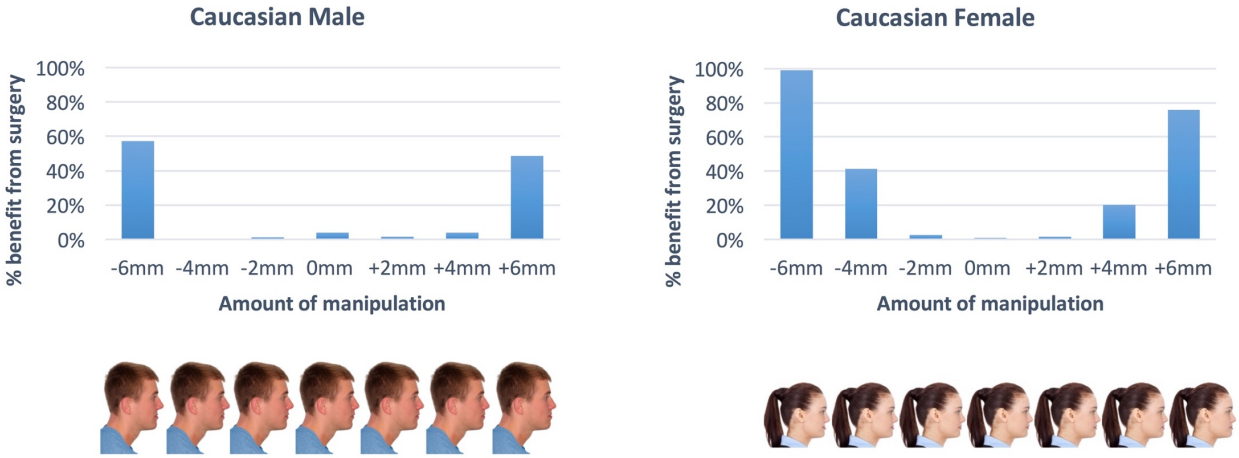


Figure 42: The proportion of responses indicating a potential benefit from surgery for Caucasian male and female images (UK responses)

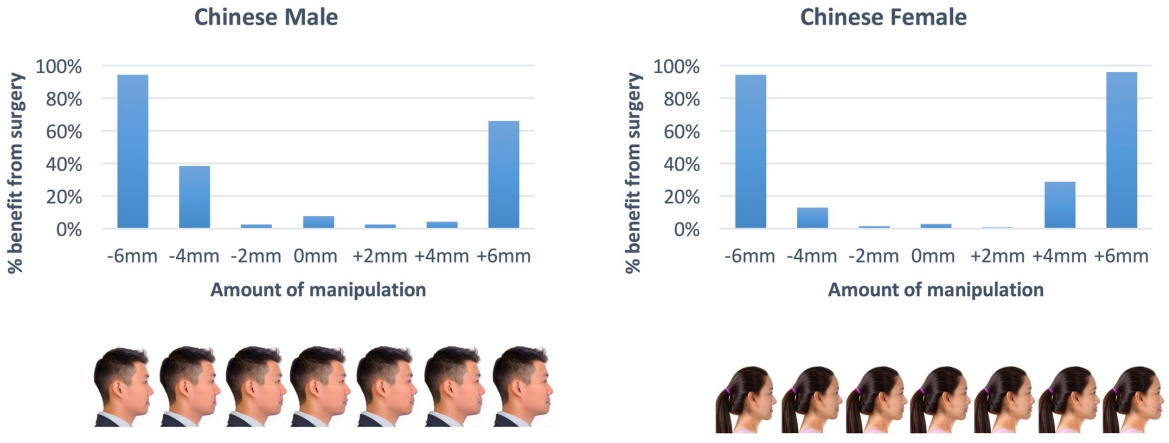


Figure 43: The proportion of responses indicating a potential benefit from surgery for Chinese female and female images (UK responses)

Variable	Odds ratio	95% confidence interval	P-value
Gender of rater (female vs male)	1.22	0.81, 1.83	0.334
Importance of attractive appearance	0.82	0.63, 1.08	0.155
Years as a consultant**	0.92	0.82, 1.02	0.116
Specialty (oral and maxillofacial surgeon vs. orthodontics)	5.66	3.38, 9.47	<0.001
Number of orthognathic patients treated per year*	1.22	1.11, 1.35	<0.001
Race of image (Chinese vs. Caucasian)	2.03	1.70, 2.42	<0.001
Gender of image (Female vs Male)	3.92	3.25, 4.72	<0.001
Manipulation (vs. none)			
Maxillary 2 mm	0.45	0.24, 0.82	0.009
Maxillary 4 mm	14.50	9.66, 21.79	<0.001
Maxillary 6 mm	842.93	532.00, >999,99	<0.001
Mandibular 2 mm	0.39	0.21, 0.74	0.004
Mandibular 4 mm	5.66	3.73, 8.60	<0.001
Mandibular 6 mm	216.25	141.10, 331.42	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

** Coefficient refers to increase of 5 years

Table 33: Multivariate logistic regressions for benefit from surgery for the United Kingdom respondents

6.4.5 Multivariate logistic regression for benefit from surgery for the United Kingdom respondents

The variables which had a statistically significant association with the recommending benefit from surgery for the images were; oral and maxillofacial surgeons, increasing numbers of orthognathic surgical cases treated per year, Chinese ethnicity and female gender, (Table 33). The number of years as a consultant was not a statistically significant variable for the United Kingdom respondents, (odds ratio = 0.92; p=0.116; 95% CI 0.82, 1.02). The variable with the greatest effect on the perception of need for surgery was the occupation of the respondent with oral and maxillofacial surgery much more likely to recommend surgery compared with orthodontists, (odds ratio = 5.66; p=<0.001; 95% CI 3.38, 9.47).

There was a statistically significant perception of benefit from surgery for all manipulations compared with the baseline image, (Table 33). The perception of benefit increased with increasing manipulation for both the maxillary and mandibular manipulations with the 6mm manipulations perceived as having the greatest benefit from surgery. The manipulation which was perceived as having the greatest benefit was the -6mm maxillary manipulation (odds ratio = 842.93; p=<0.001; 95% CI 532.00, >999,99).

The maxillary manipulations were more likely to be rated as having perceived benefit from orthognathic surgery. The perceived benefit from surgery was 1.15 greater for the -2mm maxillary manipulation, 2.56 greater for the -4mm maxillary manipulation and 3.90 greater for the -6mm maxillary manipulation compared with their corresponding mandibular manipulation.

Interpretation of the multivariate logistic regressions (Table 33), show that the odds of perceived benefit from surgery:

- Decreased by 8% for every 5-year increase in experience of consultant, however this was not significant
- Was 5.66 times greater for oral and maxillofacial surgeons than orthodontists
- Increased 2.03 times for Chinese image than Caucasian image
- Were 3.92 times greater for female images compared with male images of the same manipulation
- Were 0.45 times greater for the image that had 2mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible, however this was not statistically significant.
- Were 14.5 times higher for the image that had 4mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible.
- Were 842.93 times higher for the image that had 6mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible.

6.4.6 Perceived benefit from surgery Hong Kong

Clinicians from Hong Kong followed the same trends overall as clinicians from the United Kingdom, rating those manipulations with the most class 3 profiles as most likely to benefit from surgery, (Figure 44, Figure 45). Almost all clinicians rated the Chinese and Caucasian female -6mm maxillary manipulations as having a benefit from surgery. The maxillary manipulations were rated as most likely to benefit from surgery when compared with the same degree of mandibular manipulation, (Table 34).

Manipulation (mm)	Caucasian Male	Caucasian Female	Chinese Male	Chinese Female
0mm baseline	14.9%	6.8%	21.6%	6.8%
Mandible manipulated anteriorly from baseline:				
+2mm	8.1%	4.1%	13.5%	4.1%
+4mm	9.5%	39.2%	25.7%	45.9%
+6mm	51.4%	77%	79.7%	93.2%
Maxilla manipulated anteriorly from baseline:				
-2mm	4.1%	5.4%	20.3%	8.1%
-4mm	20.3%	63.5%	56.8%	25.7%
-6mm	66.2%	97.3%	93.2%	97.3%

Table 34: Frequencies of patient being recommended for orthognathic surgery (HK) *NB valid percentages used where marked

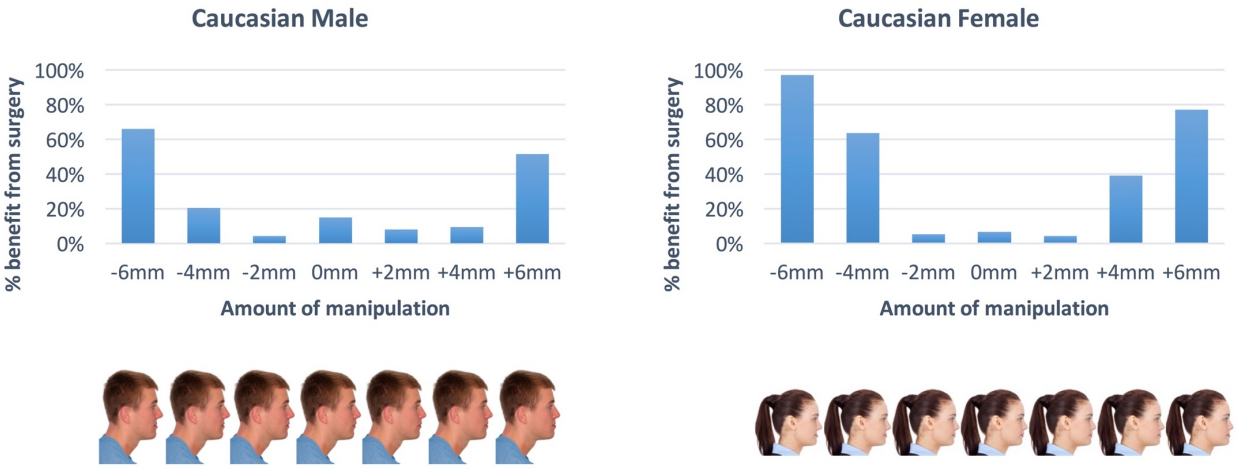


Figure 44: The proportion of responses indicating a potential benefit from surgery for Caucasian male and female images (HK responses)

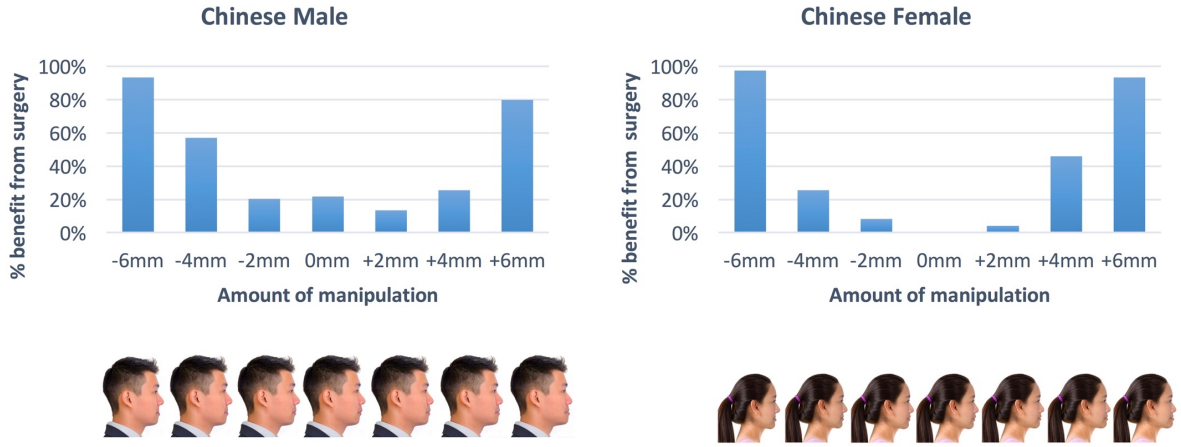


Figure 45: The proportion of responses indicating a potential benefit from surgery for Chinese female and female images (HK responses)

Variable	Odds ratio	95% confidence interval	P-value
Gender of rater (female vs male)	1.062	0.462, 2.437	0.888
Importance of attractive appearance	1.017	0.549, 1.883	0.957
Years as a specialist**	0.806	0.651, 0.998	0.048
Specialty (oral and maxillofacial surgeon vs. orthodontics)	2.382	1.168, 4.855	0.017
Number of orthognathic patients treated per year*	1.151	0.944, 1.404	0.165
Race of image (Chinese vs. Caucasian)	2.318	1.769, 3.038	<0.001
Gender of image (Female vs Male)	1.888	1.445, 2.468	<0.001
Manipulation (vs. none)			
Maxillary 2 mm	0.674	0.372, 1.218	0.191
Maxillary 4 mm	9.191	5.591, 15.044	<0.001
Maxillary 6 mm	227.691	122.799, 422.178	<0.001
Mandibular 2 mm	0.480	0.256, 0.901	0.022
Mandibular 4 mm	4.484	2.723, 7.382	<0.001
Mandibular 6 mm	70.310	40.912, 120.833	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

** Coefficient refers to increase of 5 years

Table 35: Multivariate logistic regressions for benefit from surgery for the Hong Kong respondents

6.4.7 Multivariate logistic regression for benefit from surgery for the Hong Kong respondents

The variables which had a statistically significant effect on the recommending benefit from surgery for the images were; increasing number of years as a specialist, oral and maxillofacial surgeons, Chinese ethnicity and female gender, (Table 35). The number of orthognathic cases treated per year was not statistically significant variable for the Hong Kong respondents, (odds ratio = 1.151; p=0.165; 95% CI 0.944, 1.404). The variable with the greatest effect on the perception of need for surgery was the occupation of the respondent with oral and maxillofacial surgery much more likely to recommend surgery compared with orthodontists, (odds ratio = 2.382; p=0.017; 95% CI 1.168, 4.855).

There was a statistically significant perception of benefit from surgery for all manipulations, greater than 2mm, compared with the baseline image, (Table 35). The perception of benefit increased with increasing manipulation for both the maxillary and mandibular manipulations with the 6mm manipulations perceived as having the greatest benefit from surgery. The manipulation which was perceived as having the greatest benefit was the -6mm maxillary manipulation (odds ratio = 227.691; p=<0.001; 95% CI 122.799, 422.178). Although there was benefit from surgery for the 2mm manipulations this was not statistically significant. For each increment of manipulation, the perception of benefit was greatest for maxillary retrusion compared with mandibular prognathism.

Interpretation of the multivariate logistic regressions (Table 35), show that the odds of perceived benefit from surgery:

- Decreased by 20% for every 5-year increase in experience of consultant
- Was 2.38 times greater for oral and maxillofacial surgeons than orthodontists
- Increased 2.3 times for Chinese image than Caucasian image
- Were 1.888 times greater for female images than male images of the same manipulation
- Were 1.4 times higher for the image that had 2mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible, however this was not statistically significant.
- Were 2.05 times higher for the image that had 4mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible.
- Were 3.24 times higher for the image that had 6mm manipulation of maxilla compared to the image with the same degree of manipulation in the mandible.

6.5 Perception of the importance of facial attractiveness

The respondent's perception of facial attractiveness was assessed using two individual questions relating to overall perception of importance and personal importance using a 7-point Likert scale. The first was 'How would you rate your own facial attractiveness?' and the second, 'How important do you think it is to have an attractive facial appearance?'.

6.5.1 Whole population

The majority of respondents felt that their own facial attractiveness was either slightly important or very important; very few respondents felt that it was not important, (Table 36).

Almost all clinicians felt that facial attractiveness is an important quality, however oral and maxillofacial surgeons were more likely to rate this as very important and more orthodontists as slightly important overall, (Table 37). Very few clinicians felt that an attractive facial appearance was not a desirable feature, (Figure 46). A greater proportion of respondents felt that having an attractive facial appearance in general was more important compared to the responses related to their own facial appearance.

		How would you rate your own facial attractiveness?						
		Extremely important	Very important	Slightly important	Neither important nor unimportant	Slightly unimportant	Very unimportant	**Total**
Specialty	Oral and Maxillofacial Surgeon	2	21	40	16	1	1	**81**
	Orthodontist	6	76	116	24	2	1	**225**
Total		**8**	**97**	**156**	**40**	**3**	**2**	**326**

Table 36: Rating of the importance of facial attractiveness for all respondents

		How important do you think it is to have an attractive facial appearance?						
		Extremely important	Very important	Slightly important	Neither important nor unimportant	Slightly unimportant	Very unimportant	**Total**
Specialty	Oral and Maxillofacial Surgeon	2	41	34	4	0	0	**81**
	Orthodontist	10	97	109	6	2	1	**225**
Total		**12**	**138**	**143**	**10**	**2**	**1**	**326**

Table 37: Rating of importance of own facial attractiveness for all respondents

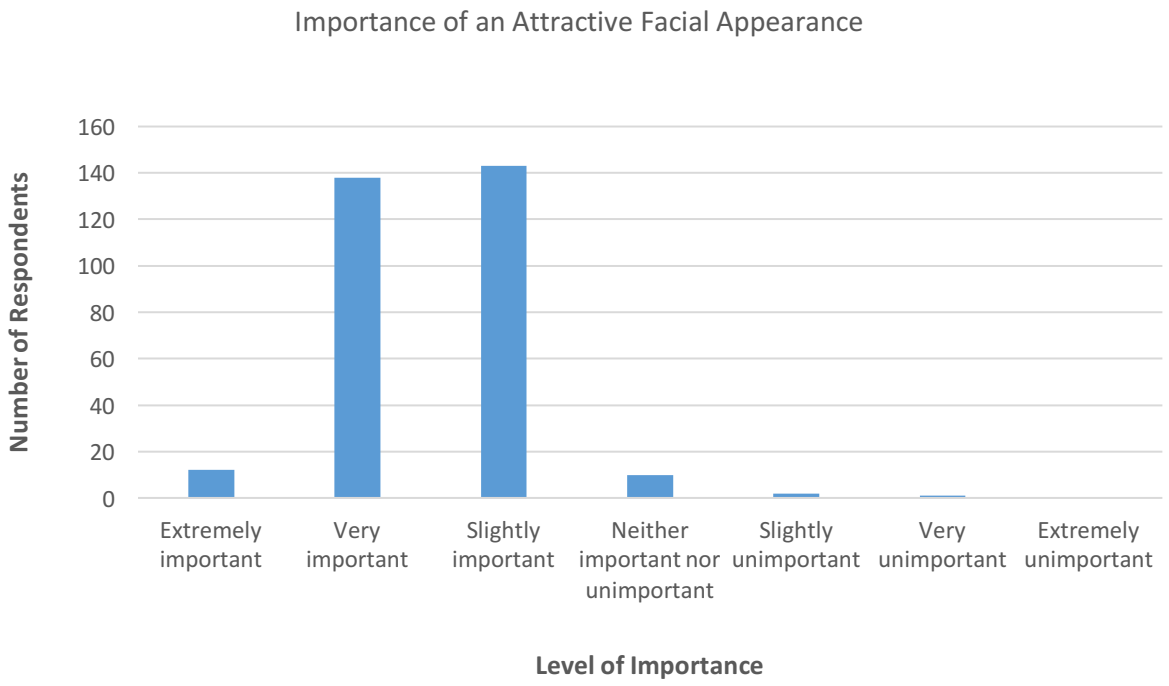


Figure 46: Overall perception of the importance of having an attractive facial appearance.

6.5.2 United Kingdom

There were similar findings for the importance of personal facial attractiveness, (Table 38). However, oral and maxillofacial surgeons placed more importance of an attractive facial appearance than orthodontists, (Table 39).

		How would you rate your own facial attractiveness?						
		Extremely important	Very important	Slightly important	Neither important nor unimportant	Slightly unimportant	Very unimportant	**Total**
Specialty	Consultant Oral and Maxillofacial Surgeon	1	9	19	11	1	1	**42**
	Consultant Orthodontist	5	58	102	22	2	1	**190**
Total		**6**	**67**	**121**	**33**	**3**	**2**	**232**

Table 38: Rating of importance of own facial attractiveness in the United Kingdom

		How important do you think it is to have an attractive facial appearance?						
		Extremely important	Very important	Slightly important	Neither important nor unimportant	Slightly unimportant	Very unimportant	**Total**
Specialty	Consultant Oral and Maxillofacial Surgeon	0	16	22	4	0	0	**42**
	Consultant Orthodontist	7	73	102	5	2	1	**190**
Total		**7**	**89**	**124**	**9**	**2**	**1**	**232**

Table 39: Rating of the importance of facial attractiveness in the United Kingdom

6.5.3 Hong Kong

The findings were similar as for the United Kingdom, with the majority of responses being 'slightly important' or 'very important'. However, no respondents from Hong Kong felt that either their own, or an attractive facial appearance in general, was unimportant. 99% of respondents from Hong Kong felt that having an attractive facial appearance was important, (Table 41).

		How would you rate your own facial attractiveness?				
		Extremely important	Very important	Slightly important	Neither important nor unimportant	**Total**
Specialty	Specialist Oral and Maxillofacial Surgeon	1	7	9	3	**20**
	Specialist Orthodontist	1	14	12	2	**29**
	Trainee Oral and Maxillofacial Surgeon	0	5	12	2	**19**
	Trainee Orthodontist	0	4	2	0	**6**
Total		**2**	**30**	**35**	**7**	**74**

Table 40: Rating of importance of own facial attractiveness in Hong Kong

		How important do you think it is to have an attractive facial appearance?				
		Extremely important	Very important	Slightly important	Neither important nor unimportant	**Total**
Specialty	Specialist Oral and Maxillofacial Surgeon	1	13	6	0	**20**
	Specialist Orthodontist	3	18	7	0	**29**
	Trainee Oral and Maxillofacial Surgeon	1	12	6	1	**19**
	Trainee Orthodontist	0	6	0	0	**6**
Total		**5**	**49**	**19**	**1**	**74**

Table 41: Rating of the importance of facial attractiveness in Hong Kong

6.6 Attractiveness rating for the whole population

Across all ethnicities and genders the same trend was observed for the attractiveness ratings; the attractiveness rating decreased with increasing manipulations in both the maxilla and mandible, (Figure 49, Figure 50). For all except Caucasian female the most attractive manipulations were those which produced a mild class 3 profiles, the +2mm and -2mm manipulations. The most class 3 profiles were the least attractive overall; this was the case for all ethnicities and genders. Of all the profiles, the images which were rated most and least attractive were both Caucasian female; the 0mm baseline was most attractive (mean 2.44, 95% CI 1.66, 3.22) and the -6mm manipulation least attractive (mean 5.6, 95% CI 4.79, 6.41), (Table 42). The Caucasian female images were the only ones for which a mild class 3 profile was not rated as most attractive overall.

For the Caucasian images the most attractive profiles differed between the genders, with the 0mm baseline profile most attractive for the female and the maxillary -2mm, mild class 3, image most attractive for the male composite. The most class 3 images were rated as least attractive for both genders, with those images where the class 3 relationship was due to maxillary retrusion rated as least attractive overall, (Table 42).

For the Chinese male and female images the most attractive profiles were mild class 3 with the -2mm maxillary retrusion images rated slightly more attractive than +2mm mandibular prognathism for both genders, (Table 42). The least attractive images were those with the most severe class 3 relationship. For the female image this was the -6mm maxillary retrusion profile, and for the male image the +6mm mandibular prognathism image.

Manipulation (mm)	Caucasian Images				Chinese Images			
	Female		Male		Female		Male	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
0	2.44	0.78	3.25	0.91	2.83	0.87	3.49	0.88
Posterior maxillary manipulation (mm)								
-2	2.5	0.77	3	0.81	2.77	0.79	3.04	0.83
-4	4.2	0.90	3.54	0.83	3.53	0.94	4.3	0.87
-6	5.6	0.81	4.56	0.81	5.35	0.82	5.16	0.82
Anterior mandibular manipulation (mm)								
+2	2.51	0.79	2.98	0.81	2.83	0.82	3.11	0.87
+4	3.7	0.95	3.25	0.77	3.97	0.92	3.47	0.86
+6	4.76	0.87	4.35	0.84	5.4	0.81	4.62	0.85

Table 42: Comparison of the respondents' ratings for attractiveness of the images for the whole population

(a) **(b)**

Figure 47: Attractiveness ratings (a) the most attractive profile. (b) the least attractive profile

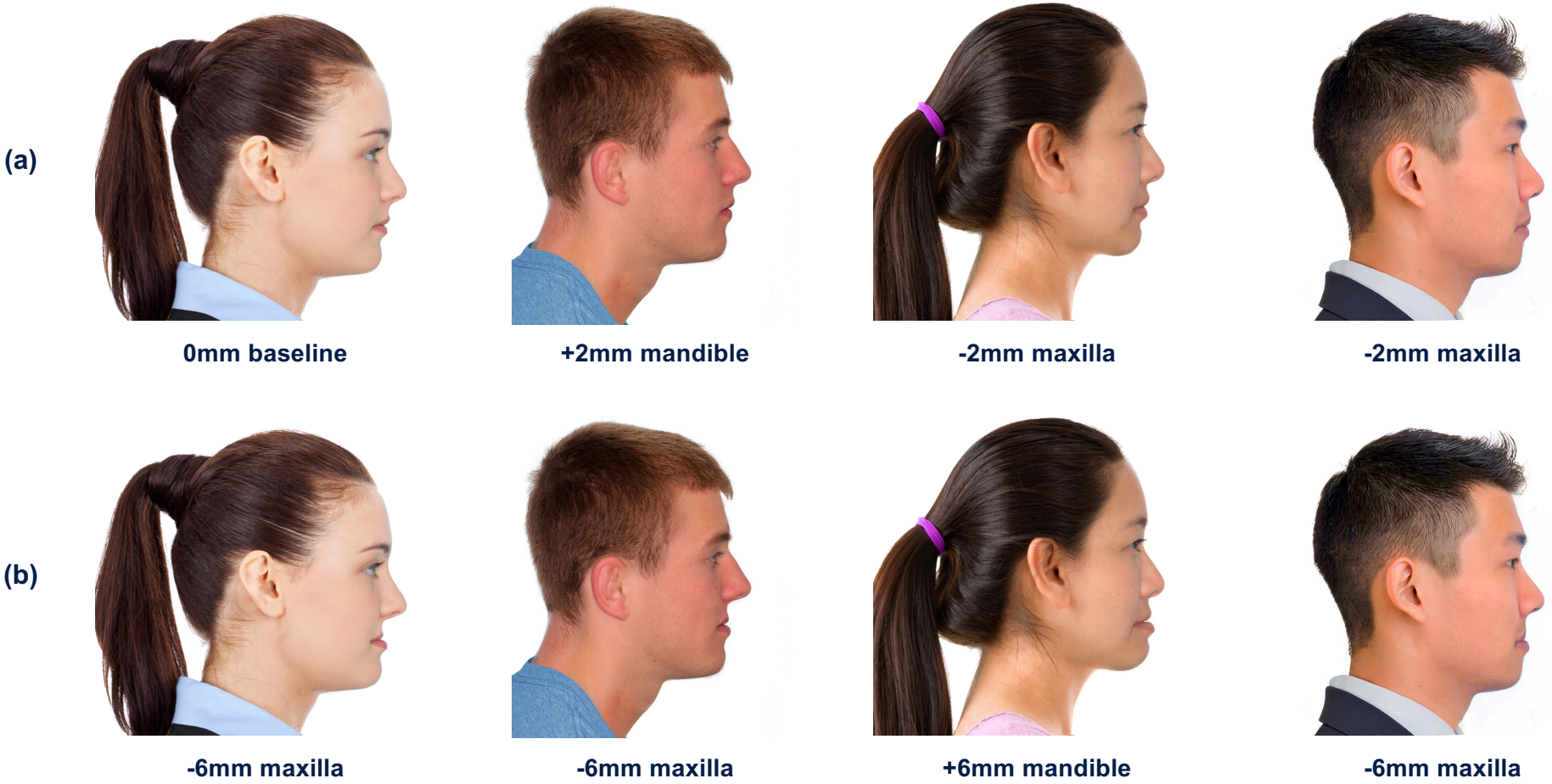
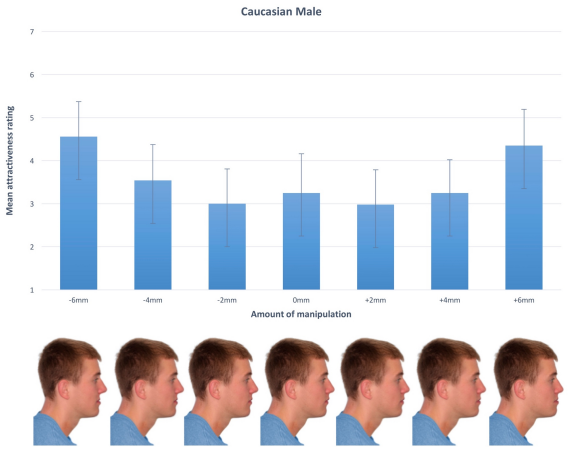


Figure 48: The images rated most (a) and least (b) attractive for each gender and ethnicity



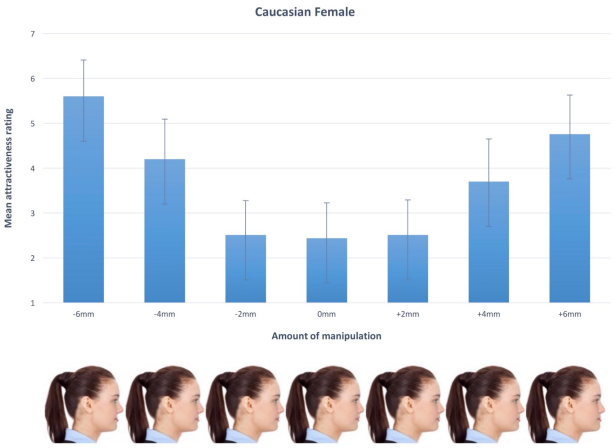
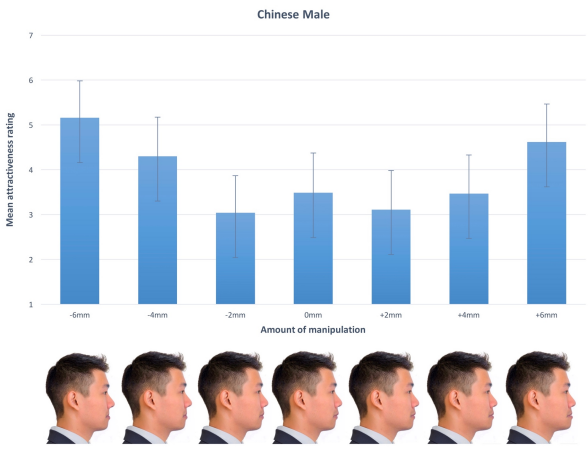


Figure 49: The mean attractiveness ratings and standard deviations for the manipulated Caucasian images by all respondents



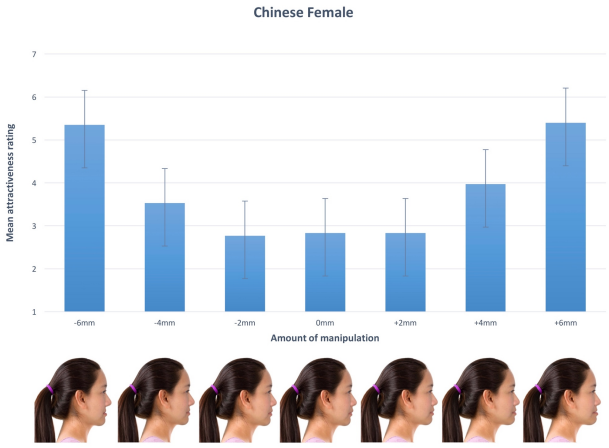


Figure 50: The mean attractiveness ratings and standard deviations for the manipulated Chinese images by all respondents

Variable	Coefficient (gradient)	95% confidence interval	P-value
Gender of rater (female vs male)	0.05	-0.06, 0.16	0.345
Importance of attractive appearance-	0.02	-0.06, 0.09	0.638
Years as a consultant**	-0.01	-0.04, 0.02	0.638
Specialty (oral and maxillofacial surgeon vs. orthodontics)	-0.10	-0.22, 0.03	0.131
Number of orthognathic patients treated per year*	0.001	-0.02, 0.03	0.345
Race of image (Chinese vs. Caucasian)	-0.23	-0.26, -0.20	<0.001
Gender of image (Female vs Male)	-0.02	-0.05, 0.01	0.231
Manipulation			
Maxillary 2 mm	0.17	-0.11, 0.24	<0.001
Maxillary 4 mm	-0.89	-0.95, -0.83	<0.001
Maxillary 6 mm	-2.17	-2.23, -2.10	<0.001
Mandibular 2 mm	0.14	0.08, 0.20	<0.001
Mandibular 4 mm	-0.59	-0.66, -0.53	<0.001
Mandibular 6 mm	-1.78	-1.84, -1.72	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

** Coefficient refers to increase of 5 years

Table 43: Multi-level linear regression for attractiveness rating for the whole population

6.6.1 Multi-level linear regression for facial attractiveness for the whole population

The only variable which was found to have a statistically significant association with the attractiveness ratings was the ethnicity of the image, with Caucasian images rated as more attractive than Chinese images; (regression coefficient = -0.23; p=<0.001; 95% CI 0.26, -0.20).

The attractiveness ratings of the manipulated images were all significantly different to that of the baseline image. The 2mm manipulations, representing very mild class 3 profiles, were both rated as statistically significantly more attractive than the baseline image overall. The -2mm maxillary manipulation was rated as the most attractive image, (regression coefficient =0.17; p=<0.001; 95% CI -0.11, 0.24). With increasingly severe manipulation the attractiveness rating reduced with the 4mm and 6mm manipulations, the more severe class 3 profiles, significantly less attractive than the baseline image. The image which was rated the least attractive was the maxillary -6mm manipulation; (regression coefficient = -2.17; p=<0.001; 95% CI -2.23, -2.10). This was the same manipulation that was rated as most likely to benefit from surgery. Overall, the maxillary manipulations; those with maxillary retrusion, were all rated as less attractive than their corresponding mandibular manipulation.

On multi-level linear regression analysis (Table 43), the rating of image attractiveness:

- Decreased by 0.1 of a level of Likert scale if the rater was an oral and maxillofacial surgeon, however this was non-significant.
- Increased by 0.001 of a level of Likert scale with every 5 patient increment increase in number of orthognathic patients treated a year, however this was non-significant.
- Decreased by 0.23 of a level of Likert scale for Chinese images compared to Caucasian images.
- Decreased by 0.02 of a level of Likert scale for female images compared to male images.
- All maxillary manipulated images were rated less attractive than mandibular manipulated images with the same degree of manipulation.

6.6.2 Attractiveness rating for the United Kingdom respondents

Across all ethnicities and genders the same trend as for the whole population was observed for the attractiveness ratings; the attractiveness rating decreased with increasing manipulations in both the maxilla and mandible, (Figure 52, Figure 53). For all except Caucasian female the most attractive manipulations were those which produced a mild class 3 profiles, the +2mm and -2mm manipulations. The most class 3 profiles were the least attractive overall; this was the case for all ethnicities and genders. Of all the profiles, the images which were rated most and least attractive were both Caucasian female. The Caucasian female images were the only ones for which a mild class 3 profile was not rated as most attractive overall. The range of attractiveness ratings for the male Caucasian images were less extreme than the profile images for the other ethnicities and genders. The maximum attractiveness ratings were smaller for the Caucasian male images than the others.

For the Caucasian images the most attractive profiles differed between the genders, with the 0mm baseline profile rated most attractive for the female and the, mild class 3 (-2mm, +2mm), images most attractive of the male images, (Table 44). The most class 3 images were rated as least attractive for both genders, with those images where the class 3 relationship was due to maxillary retrusion rated as least attractive overall, (Table 44).

For the Chinese male and female images the most attractive profiles were mild class 3 with the -2mm maxillary retrusion images rated slightly more attractive than +2mm mandibular prognathism for both genders, however the difference was small, (Table 44). The least attractive images were those with the most severe class 3 relationship. For the male image the -6mm maxillary retrusive profile was least attractive and with the mandibular prognathism image rated least attractive for the Chinese female profile.

Manipulation (mm)	Caucasian Images				Chinese Images			
	Female		Male		Female		Male	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
0	2.38	0.717	3.22	0.877	2.78	0.847	3.45	0.836
Posterior maxillary manipulation (mm)								
-2	2.42	0.723	2.98	0.806	2.7	0.757	2.97	0.81
-4	4.08	0.908	3.51	0.827	3.41	0.878	4.21	0.813
-6	5.59	0.8	4.56	0.787	5.26	0.84	5.08	0.829
Anterior mandibular manipulation (mm)								
+2	2.42	0.752	2.96	0.791	2.72	0.774	3.03	0.86
+4	3.63	0.954	3.23	0.766	3.85	0.906	3.34	0.832
+6	4.71	0.858	4.33	0.836	5.31	0.816	4.51	0.878

Table 44: Comparison of the respondents' ratings for attractiveness of the images for the United Kingdom respondents

(a) **(b)**

Figure 51: Attractiveness ratings (a) the most attractive profile. (b) the least attractive profile

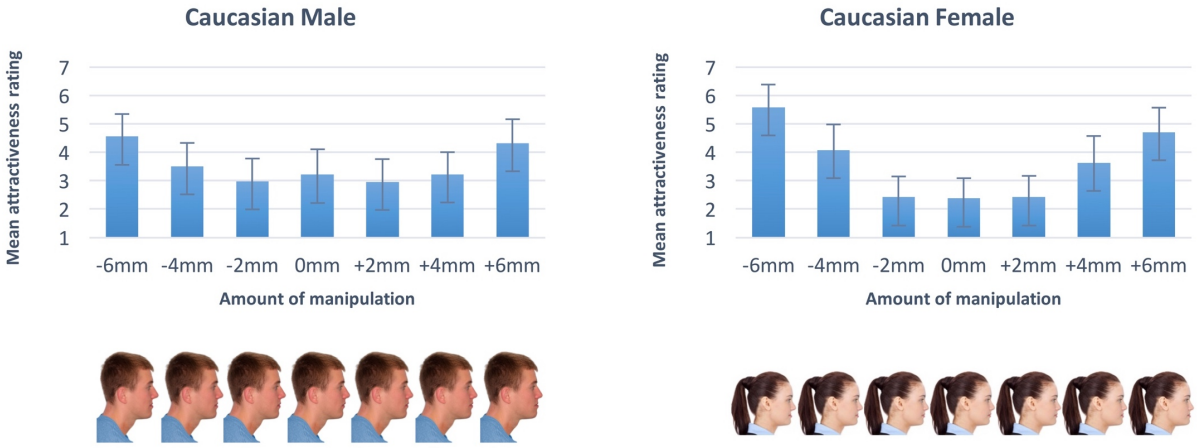


Figure 52: The mean attractiveness ratings and standard deviations for the manipulated Caucasian images by United Kingdom respondents

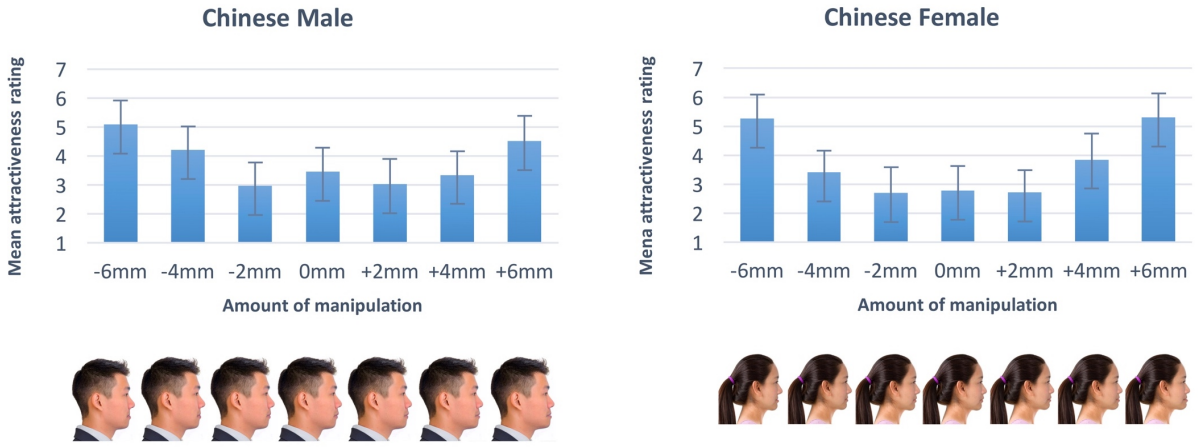


Figure 53: The mean attractiveness ratings and standard deviations for the manipulated Caucasian images by United Kingdom respondents

Variable	Coefficient (gradient)	95% confidence interval	P-value
Gender of rater (female vs male)	0.074	-0.050	0.345
Importance of attractive appearance-	0.024	-0.106, 0.058	0.571
Years as a consultant**	-0.005	-0.012, 0.001	0.127
Specialty (oral and maxillofacial surgeon vs. orthodontics)	-0.071	-0.228, 0.086	0.131
Number of orthognathic patients treated per year*	-0.010	-0.039, 0.019	0.345
Race of image (Chinese vs. Caucasian)	-0.185	-0.223, -0.147	<0.001
Gender of image (Female vs Male)	0.008	-0.030, 0.046	0.231
Manipulation			
Maxillary 2 mm	0.1886	0.118, 0.260	<0.001
Maxillary 4 mm	-0.845	-0.916, -0.773	<0.001
Maxillary 6 mm	-2.167	-2.238, -2.096	<0.001
Mandibular 2 mm	0.1724	0.101, 0.243	<0.001
Mandibular 4 mm	-0.555	-0.626, -0.484	<0.001
Mandibular 6 mm	-1.759	-1.830, -1.688	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

** Coefficient refers to increase of 5 years

Table 45: Multilinear logistic regressions for benefit from surgery for the United Kingdom respondents

6.6.3 Multi-level linear regression of facial attractiveness for the United Kingdom respondents

Only one variable had a statistically significant association with the attractiveness ratings for the clinicians based in the United Kingdom; gender. Caucasian images were rated as more attractive than Chinese images; (regression coefficient = -0.185; p=<0.001; 95% CI -0.223, -0.147), (Table 45).

The images with mild class 3 discrepancy, the 2mm manipulations in both the maxilla and mandible, were rated as more attractive than the baseline images respectively; (regression coefficient = 0.189; p=<0.001; 95% CI 0.118, 0.260; regression coefficient = 0.172; p=<0.001; 95% CI 0.101, 0.243). With increasing class 3 discrepancy, the attractiveness ratings reduced, with the most unattractive images being the 6mm manipulations; the images that were also rated as most likely to benefit from surgery. Overall, the -4mm and -6mm maxillary manipulations; those with maxillary retrusion, were all rated as less attractive than their corresponding mandibular manipulation. Conversely, the -2mm maxillary manipulation was rated as the most attractive profile overall, (Table 45).

On multi-level linear regression analysis (Table 45), the rating of image attractiveness:

- Decreased by 0.07 of a level of Likert scale if the rater was an oral and maxillofacial surgeon, however this was non-significant.
- Increased by 0.01 of a level of Likert scale with every 5 patient increment increase in number of orthognathic patients treated a year, however this was non-significant.
- Decreased by 0.185 of a level of Likert scale for Chinese images compared to Caucasian images.
- Decreased by 0.01 of a level of Likert scale for female images compared to male images, however this was non-significant.
- All maxillary manipulated images, except for -2mm, were rated less attractive than mandibular manipulated images with the same degree of manipulation.

6.6.4 Attractiveness rating for the Hong Kong respondents

Across all ethnicities and genders the same trend was observed for the attractiveness ratings as for the whole population; the attractiveness rating decreased with increasing manipulations in both the maxilla and mandible, (Figure 55, Figure 56). The most class 3 profiles were the least attractive overall. Those images with -6mm maxillary retrusion were the least attractive image for all except the Chinese female profile, which was the +6mm manipulation with mandibular prognathism. Similarly, for all except the Caucasian female images, the most attractive manipulations were those which produced a mild class 3 profile, the +2mm and -2mm manipulations.

Of all the profiles, the images which was rated most attractive was the 0mm Caucasian female; (mean 2.44, 95% CI 1.66, 3.22) and the Chinese female mandibular +6mm manipulation least attractive (mean 5.68, 95% CI 4.98, 6.39), (Figure 54).

Manipulation (mm)	Caucasian Images				Chinese Images			
	Female		Male		Female		Male	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
0	2.62	0.947	3.34	1.011	3	0.922	3.61	1.018
Posterior maxillary manipulation (mm)								
-2	2.78	0.837	3.04	0.818	2.97	0.866	3.26	0.845
-4	4.58	0.744	3.64	0.853	3.92	1.01	4.59	0.978
-6	5.61	0.857	4.57	0.877	5.64	0.695	5.42	0.74
Anterior mandibular manipulation (mm)								
+2	2.8	0.827	3.05	0.858	3.18	0.855	3.36	0.869
+4	3.91	0.924	3.32	0.778	4.34	0.885	3.88	0.827
+6	4.95	0.896	4.39	0.857	5.68	0.705	4.97	0.619

Table 46: Comparison of the respondents' ratings for attractiveness of the images for the Hong Kong respondents

(a) (b)

Figure 54: Attractiveness ratings (a) the most attractive profile. (b) the least attractive profile

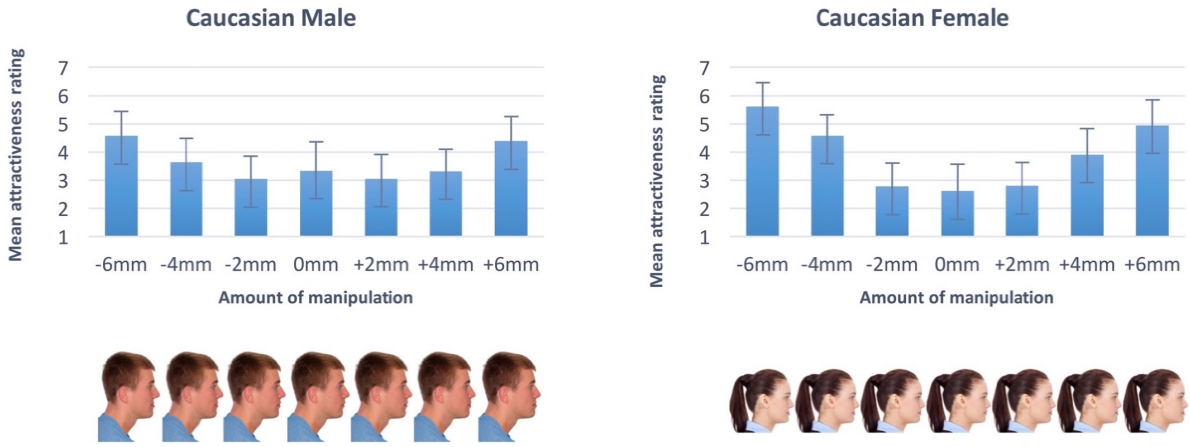


Figure 55: The mean attractiveness ratings and standard deviations for the manipulated Caucasian images by Hong Kong respondents

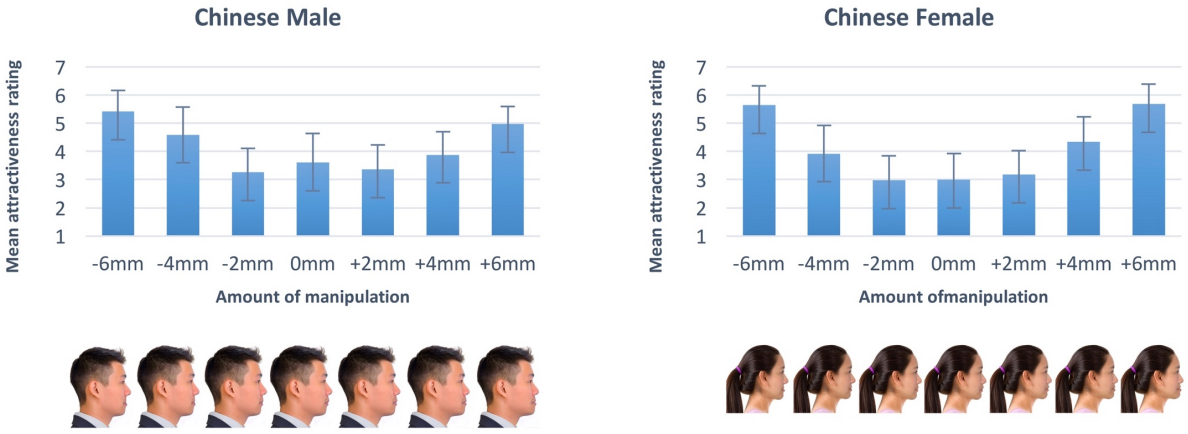


Figure 56: The mean attractiveness ratings and standard deviations for the manipulated Chinese images by Hong Kong respondents

Variable	Coefficient (gradient)	95% confidence interval	P-value
Gender of rater (female vs male)	0.058	-0.203, 0.318	0.664
Importance of attractive appearance-	-0.027	-0.220, 0.166	0.784
Years as a consultant**	0.008	-0.005, 0.021	0.231
Specialty (oral and maxillofacial surgeon vs. orthodontics)	-0.148	-0.370, 0.075	0.192
Number of orthognathic patients treated per year*	0.016	-0.047, 0.078	0.620
Race of image (Chinese vs. Caucasian)	-0.374	-0.442, -0.306	<0.001
Gender of image (Female vs Male)	-0.111	-0.179, -0.043	0.0014
Manipulation			
Maxillary 2 mm	0.126	-0.001, 0.253	0.053
Maxillary 4 mm	-1.041	-1.168, -0.914	<0.001
Maxillary 6 mm	-2.168	-2.294, -2.041	<0.001
Mandibular 2 mm	0.043	-0.084, 0.170	0.510
Mandibular 4 mm	-0.720	-0.847, -0.593	<0.001
Mandibular 6 mm	-2.168	-2.294, -2.041	<0.001

* Coefficient refers to increase of 1 category in groupings of 5 patients (0-5, 6-10, etc.)

** Coefficient refers to increase of 5 years

Table 47: Multilinear logistic regressions for benefit from surgery for the Hong Kong respondents

6.6.5 Multi-level linear regression for attractiveness for the Hong Kong respondents

Only two variables had a statistically significant association with the attractiveness ratings; ethnicity and gender. Caucasian images were rated as more attractive than Chinese images; (regression coefficient = -0.374; p=<0.0014; 95% CI -0.442, -0.306), and female images more attractive than male images; (regression coefficient = -0.111; p=<0.001; 95% CI 0.179, -0.043), (Table 47).

With increasing class 3 discrepancy, the attractiveness ratings reduced, with the most unattractive images being the 6mm manipulations; (regression coefficient = -2.17; p=<0.001; 95% CI -2.294, -2.041). These were the images that were also rated as most likely to benefit from surgery. The 2mm manipulations, representing very mild class 3 profiles, were rated as more attractive than the baseline image with the -2mm maxillary manipulation rated as the most attractive, (regression coefficient =0.126; p=0.053; 95% CI -0.001, 0.253), however this was not significant. Overall, the 4mm and 6mm maxillary manipulations; those with maxillary retrusion, were all rated as less attractive than their corresponding mandibular manipulation. Conversely, for the 2mm manipulations it was the maxillary manipulation that was rated most attractive, (Table 47).

On multi-level linear regression analysis (Table 47), the rating of image attractiveness:

- Decreased by 0.15 of a level of Likert scale if the rater was an oral and maxillofacial surgeon, however this was non-significant.
- Increased by 0.016 of a level of Likert scale with every 5 patient increment increase in number of orthognathic patients treated a year, however this was non-significant.
- Decreased by 0.37 of a level of Likert scale for Chinese images compared to Caucasian images.
- Decreased by 0.11 of a level of Likert scale for female images compared to male images.
- All maxillary manipulated images, except for -2mm, were rated less attractive than mandibular manipulated images with the same degree of manipulation.

7. Discussion

7.1 Summary of Findings

The aim of the study was to determine whether race influenced orthodontists and oral and maxillofacial surgeons' determination as to whether patients with different degrees of class 3 malocclusion would benefit from orthognathic surgery. The results demonstrated that that race was an influential factor for both attractiveness and whether clinicians felt surgery would be beneficial.

The more severe the class 3 profile, the more likely the it was to be perceived as potentially benefitting from orthognathic surgery by both orthodontists and oral and maxillofacial surgeons. There was a trend for profiles with maxillary retrusion to be recommended for surgery more frequently than those with the same degree of discrepancy due to mandibular protrusion. These were also the images which were rated as least attractive overall. This was true for patients of all ethnicities and genders and both orthodontists and oral and maxillofacial surgeons.

Oral and maxillofacial surgeons were more likely to recommend orthognathic surgery in patients with class 3 profiles than orthodontists, this was statistically significant. Those with Chinese ethnicity were more likely to be recommended for orthognathic surgery than Caucasians with the same degree of discrepancy. The multi-variable logistic regression analysis showed that the factors which influenced the decision as to whether a profile would benefit from orthognathic surgery were; female or Chinese patient, oral and maxillofacial surgeon, increasing years as a specialist and a greater number of orthognathic cases treated per year.

There were similar findings for attractiveness ratings as for potential benefit from surgery amongst clinicians. The profiles which were rated as most likely to potentially benefit from surgery were also rated as least attractive. Attractiveness ratings reduced with increasing class 3 manipulation, and for those with maxillary retrusion compared with mandibular prognathism. Interestingly, a mild class 3 skeletal pattern was found to be more attractive than the baseline image for all except the Caucasian female image. The only statistically significant factor which was found to influence attractiveness rating was the ethnicity of the image with Chinese profiles being rated as less attractive overall.

7.2 Limitations of the study

7.2.1 Ethical approval

Ethical approval took approximately 6 months to obtain in the UK and 1 month in Hong Kong. There was a significant delay in receiving financial approval from The Royal Liverpool and Broadgreen Hospital NHS Trust, despite there being no financial implications for the trust, which impacted upon the final approval. The delay in ethical approval meant that the start of questionnaire distribution occurred just after the implementation of the General Data Protection Regulation (GDPR) which had not been anticipated. This had a significant impact upon the distribution of the questionnaires to oral and maxillofacial surgeons in the United Kingdom as described below.

7.2.2 Questionnaire Distribution

The link to the online questionnaire was distributed by e-mail by the British Orthodontic Society as soon as all of the necessary approvals had been received. However, in the same week, three other questionnaires were also distributed. This may have negatively impacted on response rate due to respondent fatigue.

The process for gaining approval from the British Association of Oral and Maxillofacial Surgeons (BAOMS) for the distribution of the questionnaire was lengthy and complex, taking over 6 months to meet the requirements of their standard operating procedure for questionnaire distribution (SOP). After meeting all of the requirements, BAOMS rejected the request to distribute the questionnaire. This was in part due to the recent introduction of the General Data Protection Regulation (GDPR) which prohibited the use of members contact details without consent. As an alternative, the questionnaire with cover letter was placed in the BAOMS Forum for members who had declared a special interest in Facial Deformity surgery. This generated an automatic email to these members with a link to the online questionnaire, wit. Unfortunately, this was a very underused feature, with many members opting out of forum emails. There were no responses when the questionnaire was distributed in this manner. The distribution of the questionnaires to oral and maxillofacial surgeons in the United Kingdom was complex as they had to be contacted individually using personal contacts and hospital secretaries. However, the overall response rate was good due to the smaller numbers involved when compared with consultant orthodontists.

7.2.3 Incomplete questionnaires

There were 36 incomplete questionnaires which had to be excluded from the study, the majority of these were online (75%). When the survey was initial sent out there was a large same-day response, however many of these were incomplete. This was discovered to be due to hospital firewalls blocking the image hosting site which was used to house the images within SurveyMonkey, meaning that participants answered the demographic section but left the image assessment questions incomplete. This was rectified the same day however a lot of potential responses were lost due to this.

As the online questionnaire was anonymous the paper questionnaire was sent to all members of the Consultant Orthodontist Group of the British Orthodontic Society. Although respondents were asked not to complete the questionnaire if they had already done so online, it was not possible to check this, therefore there may have been some duplicates. There is likely to have been an unnecessary cost implication of sending the questionnaire to all members of the COG, however this could not be avoided due to the anonymity

7.2.4 Use of Composite Images

Composite images should have accounted for some of the subjectivity of clinicians in terms of the attractiveness rating due to the images being averages. However, the use of full profile images, in colour, may have influenced respondents' assessment due to their preferences for skin tone, hairstyle and clothing or other features of the image which influenced attractiveness. Although attempts were made to minimise these by using plain coloured clothing and simple hairstyles, they could not be completely controlled for. The only way to have minimised this further would have been to; crop the image so that only the profile was visible, use silhouettes or black and white images, however these would have been less realistic to the real-life clinical scenario.

7.2.5 Image selection

The images used for creation of the composites were identified from the patient records at Liverpool University Dental Hospital. Unfortunately, the quality of many of the images meant that they did not meet the inclusion criteria and were excluded. This affected, in particular, the number of Chinese images available for use, due to the relatively small numbers of patients of Chinese ethnicity treated in general. The minimum number of images required to create the composites was 4 which was achievable for both Chinese and Caucasian males and

females. However, the pool of images to choose from was much smaller for the Chinese composites.

The Psychomorph software used to create the composite images is usually used for photographs taken in the frontal view rather than profile. This was the first time that the software was used in this way and it took several weeks to familiarise with the software in order to achieve the lateral composite images.

7.2.6 Manipulations

As previously discussed in section 2.3, between 19.5%-37.5% percent of the skeletal component of class 3 malocclusions arise due to discrepancies in both the maxilla and mandible. [39, 50, 51, 112] A limitation of the study is that the manipulated images were only manipulated in one jaw at a time; either the maxilla or the mandible, not both. This therefore does not reflect a proportion of the class 3 population. However, inclusion of images in which the maxilla and the mandible were both manipulated to varying degrees would have greatly increased the number of images included in the study (and therefore reducing the participation or completion rate) and introduced multiple confounding factors (reducing the generalisability).

Patient assessment is dynamic and involves many factors, of which extra-oral assessment is just one. The use of composite profile images, whilst life-like, only allowed assessment of one facet of the malocclusion. In reality there is an assessment of the interplay between the anteroposterior, the vertical and the transverse relationship of the jaws. Although altering a single variable reduced any confounding factors, this type of manipulation is only partially representative of the real life clinical situation and therefore results of this type of study have limited generalisability. Few patients with class 3 skeletal patterns present with just an anteroposterior discrepancy. Baik *et al*, in their cohort study of Korean orthodontic patients

found that 2.5% of patients presenting with class 3 malocclusion have a concurrent facial asymmetry.[47]

7.2.7 Response Rate

The overall response rate achieved (62%) was good for a questionnaire based study. There are multiple factors which may influence the response rate including, the sample population, elements of questionnaire design such as length, wording, colour and mode of administration. The design of the questionnaire was a similar style to that which had previously been used by Al Rashidi *et al* (2016), and had achieved a good response rate.[84] Many of the principles outlined by Williams A, (2003) were factored into the design and distribution methods to increase the overall response rate of the survey, (

Table 48).

1. Use white, stamped envelopes to contact subjects.
2. Always include a pre-paid addressed envelope for respondent's replies.
3. Include a personal cover letter that has been signed in blue ink.
4. Use official-looking headed paper for all correspondence.
5. Stress the anonymity of the survey.
6. Focus the questionnaire on issues of importance to the subjects.
7. Design a questionnaire that is easy to navigate.
8. Use brightly coloured paper and add a logo to the cover of the questionnaire.
9. Send at least two reminders to non-respondents.
10. Include another copy of the questionnaire and a pre-paid envelope with each reminder.

Table 48: Recommendations for increasing response rates (Williams A., 2003)[113]

Longer questionnaires have been shown to decrease response. Due to the number of manipulated images required, there were 73 questions in total, making the questionnaire appear very lengthy to potential respondents. However, as the majority of the questions only required a dichotomous 'yes'/'no' response it was not time consuming to complete. The average time taken was recorded by SurveyMonkey to be 6 minutes and 7 seconds. As

recommended by Williams (2003), both the online and paper based questionnaire were in colour, with a copy of the university logo included at the top of each page to make it look official.113 Additionally, the British Orthodontic Society distributed the questionnaire and the pre-paid return envelope was addressed to BOS headquarters.

7.2.8 Sample

In Hong Kong, due to the relatively small numbers of specialists the questionnaire was also distributed among the trainees in orthodontics and oral and maxillofacial surgery. This increased the response rate, however the limited experience of the trainees may have affected their assessment of need for surgery and also affected other demographic variables such as age, years since qualification and number of cases treated per year. Distributing the questionnaire to trainees in orthodontics in the UK would not have been appropriate due to the differences in the provision of orthognathic surgery as only limited numbers of orthognathic cases are treated by orthodontic trainees un the UK.

7.2.9 Language

The official languages of Hong Kong are Chinese (Cantonese) and English, with Cantonese being the majority language and so not all clinicians working in Hong Kong are proficient in written or spoken English. The questionnaire was only distributed in English, without an alternative Chinese translation available. Therefore, only clinicians who were sufficiently proficient in English would have been able to complete the questionnaire. This may have introduced bias due to the potential for such clinicians to have undertaken some or all of their training oversees in the UK, USA or Australia. Clinicians who received their training in these regions may have been influenced by the racial norms of the local population, which would be majority Caucasian for English speaking countries. [64]

7.3 Provision of orthognathic surgery

Orthognathic surgery is undertaken in a multi-disciplinary setting with the input of both an orthodontist and an oral and maxillofacial surgeon. In the United Kingdom this is generally provided in a secondary care NHS setting and overseen by Consultant Orthodontists and Oral and Maxillofacial Surgeons. Patients for combined orthodontic and orthognathic treatment have to meet the minimum IOTN criteria to qualify for treatment under the National Health Service (NHS). Very small numbers of surgical cases are undertaken in private practice, mostly in larger cities such as London where this is covered by private health insurance. In the United Kingdom there are 1399 registered specialist orthodontists, of which approximately 320 are consultants[101, 114]. There are 361 consultant oral and maxillofacial surgeons, of which 49 declare facial deformity as their sub-specialty to the British Association of Oral and Maxillofacial Surgeons[102, 115]. Not all oral and maxillofacial surgeons in the UK routinely perform orthognathic surgery.

The healthcare system in Hong Kong is different to the United Kingdom with limited public healthcare and a much greater reliance on insurance based or privately funded care. When healthcare is provided in a private setting, clinicians may be more inclined towards provision of treatment. Orthognathic treatment is generally provided on a private basis and is undertaken by specialist orthodontists and oral and maxillofacial surgeons without the need for further training after specialisation. There were 65 specialist orthodontists and 59 specialist oral and maxillofacial surgeons registered with the Dental Council of Hong Kong as of the 1st January 2018.[103, 104] There is a single dental school in Hong Kong associated with The University of Hong Kong and so many practitioners gain either their primary dental qualification or specialist qualification overseas, often in western, English speaking countries such as the UK, USA or Australia.

To increase the number of clinicians with Asian Chinese ethnicity, the study was undertaken in both the UK and Hong Kong. However, the differences in the manner in which combined orthodontic and orthognathic treatment is provided between the countries may have influenced the responses given by clinicians.

7.4 Reliability Testing

Reliability testing was carried out by the placement of a duplicate maximally manipulated maxillary retrusive image of each of the four different profiles. The image used was the maxilla -6mm as this was the most extreme image and therefore least susceptible to chance. Overall there was good intra-rater reliability, however the oral and maxillofacial surgeons had only moderate reliability for the rating of benefit from surgery. Considering that the rating for attractiveness was more consistent, the difference in benefit from surgery rating is questionable. It would suggest that perhaps attractiveness is not as consistent a factor in finding potential benefit from surgery in oral and maxillofacial surgeons.

7.5 Comparison with other studies/ previous research

7.5.1 Benefit from surgery

In this study, oral and maxillofacial surgeons were more likely to perceive benefit from surgery (odds ratio = 3.94; p=<0.001; 95% CI 2.62, 5.92). Studies by Arpino *et al* and Almedia *et al*, similarly found oral and maxillofacial surgeons were more likely to recommend surgery, however their studies also included assessment by laypeople which this study did not. Unexpectedly, the findings of this study are dissimilar to those of a similar study carried out by Al Rashidi *et al* (2015) which found that there was no statistically significant difference between orthodontists and oral and maxillofacial surgeons for the perceived befit from surgery in female patients with class 3 profiles. The sample frame for this study was similar, including consultant orthodontists and oral and maxillofacial surgeons from the United Kingdom. However, this study used silhouettes rather than facial composites, assessed only female profiles and included more significant discrepancies than in this current study.

Other factors which were found to have a positive influence upon the odds of a profile being recommended for surgery were a female patient, Chinese ethnicity, increasing number of years as a specialist and the more cases treated per year. These

As class 3 malocclusion is more prevalent among those of Chinese ethnicity compared with Caucasian ethnicity. Given the increased prevalence, it could be assumed that this type of malocclusion is more acceptable in societies with a majority Chinese ethnicity. However, this was not found to be the case. With the clinicians based in Hong Kong perceiving similar benefit from surgery and attractiveness levels as the UK respondents. A similar finding was reported by Miyajima *et al* (1996) looking at Japanese immigrants to the USA, the authors hypothesised that exposure to western influences may have affected the ratings of participants. 64

The trend for images with maxillary retrusion to be more likely to be recommended as having potential benefit from surgery compared with the manipulations with mandibular prognathism has been highlighted in a previous study. 84 This is an interesting finding and may have implications for clinical practice, however there are no other studies which have investigated this phenomenon.

7.5.2 Aesthetics of facial profiles

An improvement in facial aesthetics is one of the main factors influencing patients to seek orthognathic treatment.[36] Previous studies looking at perception of facial aesthetics in patients of Chinese and Caucasian ethnicity have involved orthodontists, dentists, dental students and laypeople.[8, 82, 116, 117] There have been few previous studies looking at the assessment of class 3 profiles which have included oral and maxillofacial surgeons in those with Chinese ethnicity. This is important as a large number of patients presenting with class 3 skeletal patterns will go on to have orthognathic surgery, a multidisciplinary treatment.

The position of the upper and lower lips and chin has been found to be the most important determinant of facial attractiveness in both orthodontists and laypeople.[116] Manipulation of the skeletal bases, and subsequent impact on the soft tissues, in class 3 patients would therefore be expected to have significant impact upon perceived facial attractiveness. The results of this study would support this, as with increasing manipulation from baseline the attractiveness decreases. The profiles with the least difference between maxillary and mandibular position (and therefore lip and chin position), the 2mm manipulations, or straight profile, were found to be the most attractive in all but the Caucasian female image. This was an unexpected finding as the baseline images conformed to the gender and ethnic norms for their respective populations.

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However, interestingly this study has shown that those patients with a very mild class 3 skeletal pattern, and a straight profile, are rated similarly, or slightly more attractive than the class I profile. Similar findings amongst clinicians have been previously described by Tang *et al* (2003), Mantzikos *et al* (1998) and Maganzini *et al* (2000). [61, 63, 118,] Laypeople in a predominately Chinese Asian community were found to rate the orthognathic profiles as most attractive, and class 3 profiles least attractive.[83] Shi *et al* (2016) investigated lip position on attractiveness in manipulated profile images of Chinese boys and girls ad found that those with a straight profile were rated as more attractive. This may therefore help to influence decision making in those patients with milder class 3 profiles for whom orthodontic camouflage may be a treatment option.

7.6 Implications for clinical practice

Unlike previous similar studies, the results of this study suggest that orthodontists and oral and maxillofacial surgeons have different perceptions when assessing mild to moderate class 3 profiles. The greater the discrepancy the more likely the profile would be recommended for surgery, however, even for those manipulations which were rated as most likely to benefit from surgery there was not 100% agreement amongst clinicians. There will always be subjectivity present when assessing a patient's malocclusion. A joint orthognathic clinic assessment being beneficial for all patients for whom a skeletal discrepancy is present in order to balance the assessment of the orthodontist, oral and maxillofacial surgeon and patient when making a treatment plan.

Due to the inherent subjectivity in assessing facial attractiveness it is very difficult to quantify an ideal. The results of this study suggest that previously published facial 'norms' could be expanded as mild class 3 profiles were rated most attractive for all genders and ethnicities except Caucasian female. For those patients with mild class 3 profiles, orthodontic camouflage

may be more appropriate due to the involved in surgery. Equally, for patients with significant facial deformity, improvement towards the ideal may be sufficient. Therefore, correction to a very mild class 3 profile may be acceptable to a patient.

7.7 Implications for future research

The methodology used to create the composite and manipulated images is easily transferable to other research. It would be possible to repeat the study for patients of different ethnicities and malocclusions. The profile images included in this study were only manipulated in one dimension, anteroposteriorly. Whilst this is the most commonly assessed component of skeletal pattern when assessing a patient, it is not the only factor which contributes to malocclusion. The same methodology could also be used to assess other elements of malocclusion, including class II anteroposterior relationships, or various degrees of vertical or transverse discrepancies.

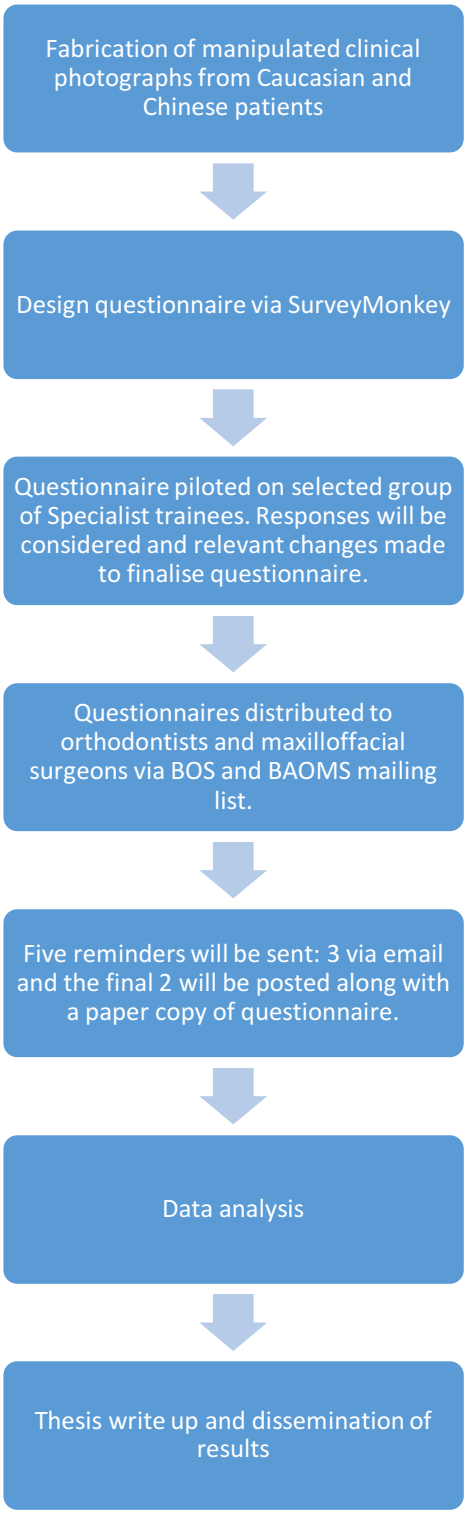
In a real-life clinical situation patients are assessed in three dimensions (3D). Profile images are a static representation of a three dimensional (3D) individual and are only partially representative of the real life clinical situation. With recent advances in 3D imaging techniques including 3D photography and stereophotogrammetry there may be the potential to undertake a similar study using images taken in this manner.

The decision to undertake orthognathic surgery is a joint one involving both clinicians and patients. Whilst it is important that orthodontists and oral and maxillofacial surgeons are on the same page, of more importance is the patients' opinion. This study looked at the perceptions of the clinicians involved in patient care, however did not look at patient factors which may influence decision making. It has been shown that patient assessment of aesthetics is not necessarily consistent with that of the orthodontist or oral and maxillofacial surgeon.[119, 116] Therefore, patients' assessment of their relative need for treatment or satisfaction with the outcome may be affected by this. There is scope to look into repeating the study with laypeople, or potential, current and previous orthognathic patients, to see whether there is similar agreement between clinicians and patients as to the potential benefit from surgery.

8. Conclusions

- The results of the study indicate that there is a statistically significant difference in the perception of the benefit from orthognathic surgery between orthodontists and oral and maxillofacial surgeons (p=<0.001) with oral and maxillofacial surgeons more likely to recommend surgery than orthodontists.
- Overall, all manipulated class 3 profiles were perceived as having benefit from orthognathic surgery compared to the baseline, with the perceived benefit increasing with increasing manipulation.
- Clinicians in Hong Kong did not perceive any potential benefit from surgery for the 2mm manipulations
- The statistically significant predictors of likelihood to perceive benefit from surgery were; female or Chinese patient, oral and maxillofacial surgeon, increasing years as a specialist, higher number of cases/year.
- Mild class 3 profiles were found to be more attractive than baseline
- The mean attractiveness ratings decreased with increasing class 3 profile (>2mm)
- Maxillary retrusion was rated less attractive than mandibular prognathism for manipulated images with the same degree of manipulation.
- Chinese profiles were rated as less attractive than Caucasian for the same manipulation

9. Summary of Study design



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11. Appendices

Appendix I: Average adult Chinese cephalometric values

	Males	Females
SNA	84 ± 4	83 ± 4
SNB	80 ± 4	81 ± 4
ANB	4 ± 2	2 ± 2
SN-MP	31 ± 4	31 ± 4
UI-MP	98 ± 6	96 ± 7
IIA	121 ± 7	124 ± 10
Wits	-4.9mm	-4.5mm
S-N mm	65 ± 4	63 ± 4
Gonial Angle	123 ± 5	123 ± 6
S-Ar-Go	146 ± 6	144 ± 0

Table: Average cephalometric norms for Chinese adults (Adapted from Moate *et al)*[65]

Appendix II: Composite adult Chinese cephalometric values

Measurement	Miao	Fu	Chan	Wei	Cheng	Lew	Miao	Fu	Wei	Cheng	Lew
SNA	85 ± 4	84 ± 4	84 ± 3	81 ± 4			85 ± 2	84 ± 4	81 ± 4		
SNB	81 ± 4	81 ± 4	80 ± 4	79 ± 5			81 ± 4	81 ± 4	80 ± 5		
ANB	4 ± 2	3 ± 2	4 ± 2	2 ± 2			4 ± 3	3 ± 2	1 ± 2		
SN-MP	29 ± 4		33 ± 4		29 ± 4		30 ± 8			31 ± 4	
UI-MP		97 ± 7	98 ± 8		96 ± 7			97 ± 7		95 ± 7	
IIA		125 ± 8	122 ± 8		124 ± 10			125 ± 8		123 ± 10	
S-N mm				65 ± 3	64 ± 4				63 ± 2	63 ± 4	
Gonial Angle	123 ± 5						122± 6				
S-Ar-Go	146 ± 6						144 ± 9				
UI-SN			107 ± 9								
N-ANS	59 ± 3	58 ± 3					53 ± 4	54 ± 3			
ANS-Me	73 ± 5	72 ± 5					68 ± 6	66 ± 4			
UFH:LFH	45:55	45:55					45:55	45:55			
SN-OP			16 ± 4		13 ± 4					13 ± 4	
LI-APog			10 ± 2		8 ± 4						
Nasolabial Angle						95°					95°

Table: Cephalometric norms for Chinese adult males and females (Adapted from Moate *et al*)[65]

Appendix III: Caucasian soft tissue norms

Table 1: Facial soft tissue anthropometric landmarks definition based on Farkas et al.[36-39]

Soft tissue anthropometric landmarks	Definition
Trichion (tr)	The most superior point on the forehead at the junction with the hairline
Soft tissue glabella (g)	The most prominent point between the eyebrows in the midsaggital plane of the forehead.
Soft tissue nasion (n)	The point of greatest concavity in the midline between the forehead and the nose
Soft tissue menton (me)	The lowest median landmark on the lower border of the mandible
Subnasale (sn)	The point located at the base of the nose
Zygion (zy)	The most lateral point of each zygomatic arch
Cheilion (ch)	The point in the junction between the upper and lower lips.
Alare (al)	The most lateral point of the lateral contour of the ala of the nose
Exocanthion (ex)	The most lateral point at the junction between the upper and lower eyelids
Endocanthion (en)	The medial point at the junction between the upper and lower eyelids.

Appendix IV: Caucasian soft tissue norms

Table 1: Facial soft tissue anthropometric landmarks definition based on Farkas et al.[36-39]

Soft tissue anthropometric landmarks	Definition
Trichion (tr)	The most superior point on the forehead at the junction with the hairline
Soft tissue glabella (g)	The most prominent point between the eyebrows in the midsaggital plane of the forehead.
Soft tissue nasion (n)	The point of greatest concavity in the midline between the forehead and the nose
Soft tissue menton (me)	The lowest median landmark on the lower border of the mandible
Subnasale (sn)	The point located at the base of the nose
Zygion (zy)	The most lateral point of each zygomatic arch
Cheilion (ch)	The point in the junction between the upper and lower lips.
Alare (al)	The most lateral point of the lateral contour of the ala of the nose
Exocanthion (ex)	The most lateral point at the junction between the upper and lower eyelids
Endocanthion (en)	The medial point at the junction between the upper and lower eyelids.

Table 2: Soft tissue measurements for Caucasian and females by Farkas et al.[36-39]

Measurement	Caucasian male	Caucasian female
Sample size	109	109
Head		
tr-n	70.1mm	63.3mm
Inclination of forehead	-9.8˚	-5.9˚
Face		
tr-g	57mm	52.7mm
n-gn	124.7mm	111.4mm
n-sto	76.4mm	69.4mm
sto-gn	50.7mm	43.4mm
sn-gn	72.6mm	64.3mm
zy-zy	144.6mm	136.2mm
go-go	107.3mm	102.3mm
Orbits		
en-en	37.6mm	36.1mm
en-ex	29.4mm	28.4mm
ex-ex	91.7mm	87.3mm
Nose		
n-sn	53.0mm	48.9mm
al-al	34.7mm	31.4mm
nasal bridge inclination	30.4 ± 3.6˚	29.9 ± 3.9˚
Nasio-labial angle	99.8 ± 11.8˚	104.2 ± 9.8˚
Nasio-frontal angle	130.3 ± 7.4˚	134.3 ± 7˚
Labio oral region		
ch-ch	53.3mm	49.8mm
Ear		
sa-sba	62.4mm	58.5mm

Appendix V: Chinese soft tissue norms

Table 3: Soft tissue measurements for Chinese males and females by Farkas *et al*.

Measurement	Chinese Male	Chinese Female
Sample size	30	30
Head		
tr-n	67.1mm	64.1mm
Inclination of forehead	-13.7˚	-9.2˚
Face		
tr-gn	187.3mm	176.2mm
n-gn	123.6mm	114.9mm
n-sto	78.2mm	71.8mm
sto-gn	53.4mm	47.2mm
sn-gn	72.8mm	66.4mm
zy-zy	144.6mm	136.3mm
go-go	107.3mm	102.3mm
Orbits		
en-en	37.6mm	36.1mm
en-ex	29.4mm	28.4mm
ex-ex	91.7mm	87.3mm
Nose		
n-sn	43.8mm	51.7mm
al-al	39.2mm	37.2mm
nasal bridge inclination	27.2 ± 3.5˚	24.5 ± 3.6˚
nasio-labial angle	86.9 ± 12.2˚	88.5 ±11.2˚
Nasio-frontal angle	134.5 ± 7˚	135.6 ± 4.4˚
Labio-oral region		
ch-ch	49.6mm	47.3mm
Ear		
sa-sba	60.7mm	57.6mm

Appendix VI: Research Ethics Committee (REC) Favourable Opinion

NHS
Health Research Authority
London - Camden & Kings Cross Research Ethics Committee
Jarrow Business Centre
Rolling Mill Road
Jarrow
NE32 3DT

Telephone: 0207 104 8086

Please note: This is the favourable opinion of the REC only and does not allow you to start your study at NHS sites in England until you receive HRA Approval

25 October 2017

Dr Norah Flannigan
Department of Orthodontics, School of Dentistry
Pembroke Place
Liverpool
L3 5PS

Dear Dr Flannigan

Study title:	**The use of clinical photographs to determine clinician's perception of the need for orthognathic surgery in patients of different racial backgrounds presenting with a class III skeletal discrepancy.**
REC reference:	**17/LO/1841**
Protocol number:	**UoL001238**
IRAS project ID:	**219012**

The Proportionate Review Sub-committee of the London - Camden & Kings Cross Research Ethics Committee reviewed the above application in correspondence.

We plan to publish your research summary wording for the above study on the HRA website, together with your contact details. Publication will be no earlier than three months from the date of this favourable opinion letter. The expectation is that this information will be published for all studies that receive an ethical opinion but should you wish to provide a substitute contact point, wish to make a request to defer, or require further information, please contact hra.studyregistration@nhs.net outlining the reasons for your request. Under very limited circumstances (e.g. for student research which has received an unfavourable opinion), it may be possible to grant an exemption to the publication of the study.

Ethical opinion

On behalf of the Committee, the sub-committee gave a **favourable ethical opinion** of the above research on the basis described in the application form, protocol and supporting documentation, subject to the conditions specified below.

Conditions of the favourable opinion

The REC favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements. Each NHS organisation must confirm through the signing of agreements and/or other documents that it has given permission for the research to proceed (except where explicitly specified otherwise).

Guidance on applying for HRA Approval (England)/ NHS permission for research is available in the Integrated Research Application System, www.hra.nhs.uk or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of management permissions from host organisations.

Registration of Clinical Trials

All clinical trials (defined as the first four categories on the IRAS filter page) must be registered on a publically accessible database. This should be before the first participant is recruited but no later than 6 weeks after recruitment of the first participant.

There is no requirement to separately notify the REC but you should do so at the earliest opportunity e.g. when submitting an amendment. We will audit the registration details as part of the annual progress reporting process.

To ensure transparency in research, we strongly recommend that all research is registered but for non-clinical trials this is not currently mandatory.

If a sponsor wishes to request a deferral for study registration within the required timeframe, they should contact hra.studyregistration@nhs.net. The expectation is that all clinical trials will be registered, however, in exceptional circumstances non registration may be permissible with prior agreement from the HRA. Guidance on where to register is provided on the HRA website.

It is the responsibility of the sponsor to ensure that all the conditions are complied with

before the start of the study or its initiation at a particular site (as applicable).

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion").

Approved documents

The documents reviewed and approved were:

Document	*Version*	*Date*
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only) [University of Liverpool Insurance]	1	30 September 2017
IRAS Application Form [IRAS_Form_06102017]		06 October 2017
IRAS Checklist XML [Checklist_12102017]		12 October 2017
Letters of invitation to participant [Letter of Invitation]	1	22 May 2017
Non-validated questionnaire [SurveyMonkey Survey]	1	30 September 2017
Other [G Burnside CV]	1	12 October 2017
Other [L Cooper CV]	1	12 October 2017
Participant information sheet (PIS) [Participant Information Sheet]	1	22 May 2017
Research protocol or project proposal [Research Protocol DDSc]	1	22 May 2017
Summary CV for Chief Investigator (CI) [N Flannigan CV]	1	30 September 2017
Summary CV for student [Jennifer Vesey CV]	1	22 May 2017
Summary CV for supervisor (student research) [N Flannigan CV]	1	30 September 2017
Summary, synopsis or diagram (flowchart) of protocol in non technical language [Protocol Summary Diagram]	1	22 May 2017

Membership of the Proportionate Review Sub-Committee

The members of the Sub-Committee who took part in the review are listed on the attached sheet.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The HRA website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

User Feedback

The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website:
http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance/

HRA Training

We are pleased to welcome researchers and R&D staff at our training days – see details at http://www.hra.nhs.uk/hra-training/

With the Committee's best wishes for the success of this project.

17/LO/1841	**Please quote this number on all correspondence**

Yours sincerely

pp

Ms Eleni Yerolaki
Alternate Vice Chair

Email: nrescommittee.london-camdenandkingscross@nhs.net

Enclosures:	*List of names and professions of members who took part in the review*
	"After ethical review – guidance for researchers"
Copy to:	*Mr Alex Astor, University of Liverpool*
	Julia West, Royal Liverpool And Broadgreen University Hospitals NHS Trust

London - Camden & Kings Cross Research Ethics Committee

Attendance at PRS Sub-Committee of the REC meeting in correspondence

Committee Members:

Name	*Profession*	*Present*	*Notes*
Dr Lorraine Ludman	Chartered Psychologist	Yes	
Dr Andy Petros	Consultant Paediatric Intensivist	Yes	
Ms Eleni Yerolaki (Alternate Vice Chair)	Specialist Counsellor	Yes	Chair of Sub-Committee

Also in attendance:

Name	*Position (or reason for attending)*
Miss Christie Ord	REC Manager

Appendix VII: University of Liverpool Sponsorship Approval

Dr Flannigan
University of Liverpool
Pembroke Place
Liverpool
Merseyside
L3 5PS

Mr Alex Astor
Head of Research Support – Health and Life Sciences

University of Liverpool
Research Support Office
2nd Floor Block D Waterhouse Building
3 Brownlow Street
Liverpool
L69 3GL

Tel: 0151 794 8739
Email: sponsor@liv.ac.uk

16 January 2018

Sponsor Ref: UoL001238

Re: Sponsor Permission to Proceed notification

"The use of clinical photographs to determine clinician's perception of the need for Orthognathic Surgery in patients of different racial backgrounds presenting with Class III skeletal discrepancy"

Dear Dr Flannigan

All necessary documentation and regulatory approvals have now been received by the University of Liverpool Research Support Office in its capacity as Sponsor, and we are satisfied that all Clinical Research Governance requirements have been met. You may now proceed with any study specific procedures to open the study.

The following REC Approved documents have been received by the Research Support Office. Only these documents can be used in the recruitment of participants. If any amendments are required please contact the Research Support Office.

Document title	Version	Date
Protocol	1	5/07/2016

Please note, under the terms of your Sponsorship you must;

1. Gain NHS Confirmation of Capacity and Capability/Site Permission from each participating site before recruitment begins at that site;

2. Ensure all required contracts are fully executed before recruitment begins at any site;

3. Inform the Research Support Office as soon as possible of any adverse events especially SUSARs and SAE's, Serious Breaches to protocol or relevant legislation or any concerns regarding research conduct;

4. Approval must be gained from the Research Support Office for any amendments to, or changes of status in the study **prior to** submission to REC and any other regulatory authorities (as per SOP018);

5. It is a requirement that Annual Progress Reports are sent to the NHS Research Ethics Committee (REC) annually following the date of Favourable Ethical Approval. You must provide copies of any reports submitted to REC and other regulatory authorities to the Research Support Office;

6. Maintain the study master file (as per SOP005);

7. Make available for review any study documentation when requested by the sponsors and regulatory authorities for the purposes of audit or inspection;

8. Upon the completion of the study it is a requirement to submit an End of Study Declaration (within 90 days of the end of the study) and End of Study Report to REC (within 12 months of the end of the study). You must provide copies of this to the Research Support Office;

9. Ensure you and your study team are up to date with the current RSO SOPs throughout the duration of the study.

If you have any queries regarding the sponsorship of the study please do not hesitate to contact the Clinical Research Governance Team on 0151 794 8373 (email sponsor@liv.ac.uk).

Yours sincerely

Mr Alex Astor
Head of Research Support – Health and Life Sciences
Research Support Office

Appendix VIII: Hong Kong Ethical Approval

香港大學
University of Hong Kong

醫院管理局
HOSPITAL AUTHORITY

香港大學及醫管局港島西醫院聯網研究倫理委員會

Institutional Review Board of the University of Hong Kong/
Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB)

Address: Rm 901, 9/F, Administration Block, Queen Mary Hospital, 102 Pokfulam Road, Hong Kong Tel 2255 3923 2255 4086

Dr. YY Leung
Dentistry
(Oral and Maxillofacial Surgery, 2/F., Prince Philip Dental Hospital), HKU
09-Apr-18

Dear Dr. Leung,

IRB Reference Number: **UW 18-260**

The HKU/HA HKW IRB is authorized by a joint agreement of the University of Hong Kong and Hospital Authority Hong Kong West Cluster to review and monitor clinical research. It serves to ensure that research complies with the Declaration of Helsinki and acts in accordance to ICH GCP guidelines, local regulations and Hospital Authority and the University policies.

In accordance with our standard operating procedures, we have duly performed ethics and scientific review of your application/submission. We hereby write to inform you that your application/ submission has been approved, on the above date, by an expedited process with details shown below.

Protocol title	:	The Use of Clinical Photographs to Determine Clinical's Perception of the Need for Orthognathic Surgery in Patients of Different Racial Backgrounds Presenting with Class III Skeletal Discrepancy
Study site(s)	:	As stated in application form
IRB reviewer	:	Professor W K Leung, Deputy Chairman of the HKU/HA HKW IRB
Document(s) approved	:	01. Clinical Research Ethics Review Application Form
	:	02. Study Protocol; Version 1 dated 6 March 2018
	:	03. Information Sheet; Version 1 dated 22 March 2018 (English)
	:	04. Invitation Letter; Version 1 dated 22 March 2018 (English)
	:	05. Questionnaire; Version 1 dated 22 March 2018 (English)
Document(s) reviewed	:	06. Short CV of Principal Investigator
Regular Progress Report(s) Required	:	Every 12 months from the date of initial approval and during the period of the study

You, being the principal investigator of the study at your study site, are reminded to comply with our requirements and to maintain communication with us during the period of the study by undertaking the principal investigator's responsibilities including (but not limited to):

- if the study is an industry-sponsored clinical study, submitting to us a copy of the fully executed indemnity agreement satisfying the Hospital Authority's requirement prior to commencement of the study (if it has not been submitted yet);
- observing and complying with all applicable requirements under our standard operating procedure ("HKU/HA HKW IRB SOP"), the Declaration of Helsinki and the ICH GCP (if applicable)
- submitting regular progress report(s) at the required intervals (as specified above) in accordance with the requirements in the IRB SOP;
- not implementing any amendment/change to any approved study document/material without our written approval, except where necessary to eliminate any immediate hazard to the subjects or if an amendment/change is only of an administrative or logistical nature;
- notifying us of any new information that may adversely affect the rights, safety or well-being of the subjects or the proper conduct of the study;
- reporting any deviation from the study protocol or compliance incident that has occurred during the study and may adversely affect the rights, safety or well-being of any subject in accordance with the requirements in the IRB SOP;

- submitting safety reports on all SAEs observed at your study site or SUSARs reported from outside your study site in accordance with the requirements in the IRB SOP; and
- submitting a final report in accordance with the requirements in the IRB SOP upon completion or termination of the study at your study site.

In addition to the above, you are also reminded to observe and comply with other applicable regulatory and management requirements including (but not limited to):

- if required by Hong Kong laws or regulations, obtaining a certificate for clinical trial through the Hong Kong Department of Health and complying with the associated requirements; and
- obtaining the necessary consent from the management of your institution/department in accordance with the requirements of your institution/department; and
- obtaining prior approval before commencing the study from the appropriate head(s) of the study site (e.g. Head / COS / Nurse Manager / Department Manager etc) with regards to the use of facilities and subject recruitment logistics/arrangement. It is advisable to print IRB's Reference Number on all recruitment materials for potential and actual study participants.
- **comply with the new reporting requirement of study results with effect from June 2015 as stated in the World Health Organization (WHO) Statement on Public Disclosure of Clinical Trial Results for any phases of clinical trials on: (1) the main findings within 12 months, or at most within 24 month, of study completion, and (2) the key outcomes within 12 months of study completion. These results must be posted in a free-to-access, public available, searchable clinical trial registry. The full text of the WHO Statement is available in http://www.who.int/ictrp/results/reporting/en/**

Yours sincerely,

Mr. Chris Yip
HKU/HA HKW IRB Secretary

Appendix IX: Recognition of Hong Kong Ethical Approval

Health and Life Sciences Research Ethics Committee (Psychology, Health and Society)

21 June 2018

Dear Dr Flannigan

I am pleased to inform you that your application for research ethics approval has been approved. Application details and conditions of approval can be found below. Appendix A contains a list of documents approved by the Committee.

Application Details

Reference:	3624
Project Title:	Clinician's perception of class 3 malocclusion using photographs
Principal Investigator/Supervisor:	Dr Norah Flannigan
Co-Investigator(s):	Miss Jennifer Vesey, Dr Girvan Burnside
Lead Student Investigator:	-
Department:	School of Dentistry
Approval Date:	21/06/2018
Approval Expiry Date:	Five years from the approval date listed above

The application was **APPROVED** subject to the following conditions:

Conditions of approval

- All serious adverse events must be reported via the Research Integrity and Ethics Team (ethics@liverpool.ac.uk) within 24 hours of their occurrence.
- If you wish to extend the duration of the study beyond the research ethics approval expiry date listed above, a new application should be submitted.
- If you wish to make an amendment to the research, please create and submit an amendment form using the research ethics system.
- If the named Principal Investigator or Supervisor leaves the employment of the University during the course of this approval, the approval will lapse. Therefore it will be necessary to create and submit an amendment form using the research ethics system.
- It is the responsibility of the Principal Investigator/Supervisor to inform all the investigators of the terms of the approval.

Kind regards,

Health and Life Sciences Research Ethics Committee (Psychology, Health and Society)

iphsrec@liverpool.ac.uk

0151 795 5420

Appendix - Approved Documents

(Relevant only to amendments involving changes to the study documentation)

Appendix X: Invitation letter (UK online and paper version)

UNIVERSITY OF LIVERPOOL

Perception of the Need for Orthognathic Surgery

Introduction

Invitation Letter

Dear Consultant,

I would like to invite you to participate in a questionnaire about the 'Perception of Need for Orthognathic Surgery' which is part of a research dissertation associated with the DDSc programme at the University of Liverpool. This study includes computer manipulated clinical photographs of patients of different racial groups (Caucasian and Chinese).

I will kindly ask you to spend no more than 30 seconds looking at each photograph and then answer the following questions:

"Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?"

"How do you rate the level of attractiveness of this profile"

I understand that in a real-life clinical scenario, the decision for surgery would be based on a wide range of records, but for the purposes of this study a distinct 'yes' or 'no' answer will be required.

The questionnaire is anonymous but a code is used to allow us to follow up those who have not responded. The codes will be kept by the research team for follow up purposes only, and this will be destroyed once the data is collected.

By reading this letter, and completing the survey, you are consenting to participate in this study. A paper copy will be sent to you within the next 6 weeks, if you prefer not to complete the questionnaire online.

We greatly appreciate your help with this study.

Kindest regards,

Dr N.L. Flannigan
Senior Clinical Lecturer/Honorary Consultant in Orthodontics
Liverpool University Dental Hospital and School of Dentistry

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Appendix XI: Invitation Letter (HK online version)

UNIVERSITY OF LIVERPOOL

Perception of the Need for Orthognathic Surgery

The Use of Clinical Photographs to Determine Clinical's Perception of the Need for Orthognathic Surgery in Patients of Different Racial Backgrounds Presenting with Class III Skeletal Discrepancy

Information Sheet

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. You may ask questions if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Background of the study

A recent project completed in Liverpool University Dental Hospital by Al Rashidi et al. has investigated the effect of patient's ethnicity on clinical decision making. This was a questionnaire based study which explored both orthodontist's and oral and maxillofacial surgeon's perception of the need for orthognathic surgery in varying degrees of Class III malocclusions of both Caucasian and Chinese individuals. The questionnaire consisted of two profile silhouettes, representing Caucasian and Chinese norms which were manipulated to show varying degrees of Class III malocclusion and was distributed to all UK Consultant Orthodontists and Orla and Maxillofacial surgeons. The study will explore the extent to which maxillary retrusion and mandibular prognathism influences whether clinicians recommend surgery or not, and investigate whether the patient's ethnicity influences clinician's decision making in recommending orthognathic surgery.

The original research project is being undertaken at The University of Liverpool, UK. The majority of patients and clinicians in the United Kingdom are of Caucasian background. This may mean that the assessment of whether surgery may be recommended for individuals of Chinese ethnicity may be influenced significantly by the clinician's own ethnicity. We considered whether this may affect our results and were hoping to repeat the study in Hong Kong where the majority of patients and clinicians are of Chinese ethnicity for comparison.

Aim of study

To investigate the impact of patient's race on clinician's perception of the need for orthognathic surgery in patients with class III skeletal profiles.

Risks and benefits of joining the study

This study does not place any serious risk or discomfort to participants. There is no intended benefit to the participant form taking part in the study.

Study procedures

Participant simply follow the instructions in the survey and complete all the questions. The survey will take around 10 minutes to complete.

Rights of participants

It is totally up to you to decide whether or not to take part. If you do decided to take part, you will be guided to complete the survey. If you decide to take part, you are still free to withdraw at any time without giving reasons.

1

Privacy of participants

Under the laws of Hong Kong (in particular the Personal Data (Privacy) Ordinance, Cap 486), you enjoy or may enjoy rights for the protection of the confidentiality of your personal data, such as those regarding the collection, custody, retention, management, control, use (including analysis or comparison), transfer in or out of Hong Kong, non-disclosure, erasure and/or in any way dealing with or disposing of any of your personal data in or for this study. For any query, you should consult the Privacy Commissioner for Privacy Data or his office (Tel No. 2827 2827) as to the proper monitoring or supervision of your personal data protection so that your full awareness and understanding of the significance of compliance with the law governing privacy data is assured.

By consenting to participate in this study, you expressly authorize: the principal investigator and his research team and the ethics committee (Institutional Review Board of the University of Hong Kong / Hospital Authority Hong Kong West Cluster) responsible for overseeing this study to get access to, to use, and to retain your personal data for the purposes and in the manner described in this informed consent process; and the relevant government agencies (e.g. the Hong Kong Department of Health) to get access to your personal data for the purposes of checking and verifying the integrity of study data and assessing compliance with the study protocol and relevant requirements.

All information acquired will be kept confidential. The data collected will be kept for 3 years and used for scientific analyses. You have the right to withdraw from the study any time. For any enquiries please contact Dr Mike YY Leung at 28590511 during office hour. This study has been reviewed and approved by Institutional Review Board of the University of Hong Kong / Hospital Authority Hong Kong West Cluster.

Organizer of the research study

The original research project is being undertaken at The University of Liverpool, UK. The project received expedited ethical approval (proportionate review) in the UK from NHS REC (17/LO/1841) and also the University of Liverpool Health and Life Sciences Research Ethics Committee (1640).

Appendix XII: Questionnaire before multi-level block randomisation (online version)

UNIVERSITY OF LIVERPOOL

Perception of the Need for Orthognathic Surgery

Introduction

Invitation Letter

Dear Colleague,

I would like to invite you to participate in a questionnaire about the 'Perception of Need for Orthognathic Surgery' which is part of a research dissertation associated with the DDSc programme at the University of Liverpool. This study includes computer manipulated clinical photographs of patients of different racial groups (Caucasian and Chinese). It should take no longer than 10 minutes to complete.

I will kindly ask you to spend no more than 30 seconds looking at each photograph and then answer the following questions:

"Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?"

"How do you rate the level of attractiveness of this profile"

I understand that in a real-life clinical scenario, the decision for surgery would be based on a wide range of records, but for the purposes of this study a distinct 'yes' or 'no' answer will be required.

The questionnaire is anonymous. By reading this letter, and completing the survey, you are consenting to participate in this study. A paper copy will be sent to you within the next 6 weeks, if you prefer not to complete the questionnaire online.

We greatly appreciate your help with this study.

Kindest regards,

Dr N.L. Flannigan
Senior Clinical Lecturer/Honorary Consultant in Orthodontics
Liverpool University Dental Hospital and School of Dentistry, UK

Jennifer Vesey
Speciality Registrar in Orthodontics
Liverpool University Dental Hospital/Countess of Chester Hospital, UK

UNIVERSITY OF LIVERPOOL

Perception of the Need for Orthognathic Surgery

Section 1: About yourself

Please answer the following questions

*** 1. How old are you?**

*** 2. What is your gender?**

- Female
- Male

*** 3. What is your ethnicity?**

- White British
- White Irish
- Asian Chinese
- Asian Indian
- Other (please specify)
- Asian Pakistani
- Asian Bangladeshi
- Black African
- Black Caribbean

UNIVERSITY OF LIVERPOOL

Perception of the Need for Orthognathic Surgery

Section 2: About your current profession

*** 4. How many years have you been a specialist?**

*** 5. Speciality**

- ○ Specialist Orthodontist
- ○ Trainee Orthodontist
- ○ Specialist Oral and Maxillofacial Surgeon
- ○ Trainee Oral and Maxillofacial Surgeon
- ○ Other (please specify)

*** 6. How many orthognathic cases do you treat each year?**

- ○ 0 - 5
- ○ 21 - 25
- ○ 6 - 10
- ○ 26 - 30
- ○ 11 - 15
- ○ > 30
- ○ 16 - 20

*** 7. In which region do you work predominantly?**

- ○ Central and Western
- ○ Islands
- ○ Eastern
- ○ Kwai Tsing
- ○ Southern
- ○ North
- ○ Wan Chai
- ○ Sai Kung
- ○ Kowloon City
- ○ Sha Tin
- ○ Kwun Tong
- ○ Tai Po
- ○ Sham Shui Po
- ○ Tsuen Wan
- ○ Wong Tai Sin
- ○ Tuen Mun
- ○ Yau Tsim Mong
- ○ Yuen Long
- ○ Other (please specify)

UNIVERSITY OF LIVERPOOL

Perception of the Need for Orthognathic Surgery

Section 3: Your attitude towards facial appearance

*** 8. How would you rate your own facial attractiveness?**

Extremely important	Very important	Slightly important	Neither important nor unimportant	Slightly unimportant	Very unimportant	Extremely unimportant
○	○	○	○	○	○	○

*** 9. How important do you think it is to have an attractive facial appearance?**

Extremely important	Very important	Slightly important	Neither important not unimportant	Slightly unimportant	Very unimportant	Extremely unimportant
○	○	○	○	○	○	○

UNIVERSITY OF LIVERPOOL

Perception of the Need for Orthognathic Surgery

Please spend no longer than 30 seconds looking at each image and answer the questions as best as possible

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Perception of the Need for Orthognathic Surgery

Section 4: Profile assessment

*** 10.**
Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?

- ◯ Yes
- ◯ No

*** 11. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 12. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 13. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 14. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 15. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 16. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 17. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 18. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 19. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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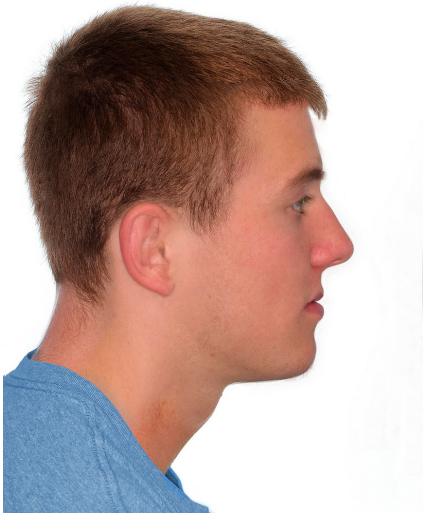
Perception of the Need for Orthognathic Surgery

*** 20. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**



- ◯ Yes
- ◯ No

*** 21. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 22. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 23. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 24. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 25. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 26. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 27. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 28. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 29. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 30. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 31. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 32. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ○ Yes
- ○ No

*** 33. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
○	○	○	○	○	○	○

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Perception of the Need for Orthognathic Surgery

*** 34. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 35. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 36. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 37. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 38. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 39. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 40. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 41. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 42. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 43. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 44. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 45. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 46. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 47. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 48. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 49. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 50. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 51. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 52. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 53. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 54. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 55. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 56. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 57. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 58. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 59. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 60. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 61. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 62. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 63. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 64. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 65. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 66. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 67. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 68. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 69. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 70. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 71. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

*** 72. Do you think that a patient, presenting with this profile, would benefit from orthognathic surgery?**

- ◯ Yes
- ◯ No

*** 73. How do you rate the level of attractiveness for this profile?**

Extremely attractive	Very attractive	Slightly attractive	Neither attractive nor unattractive	Slightly unattractive	Very unattractive	Extremely unattractive
◯	◯	◯	◯	◯	◯	◯

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Perception of the Need for Orthognathic Surgery

End of Questionnaire

Thank you for completing the questionnaire - your help with this project is really appreciated.

Appendix XIII: Question order for paper questionnaire

Question number	Ethnicity/gender	Amount of manipulation
10	Chinese female	0mm
12		-4mm maxilla
14		-2mm maxilla
16		+2mm mandible
18		+6mm mandible
20		-6mm maxilla (duplicate)
22		+4mm mandible
24		-6mm maxilla
26	Chinese male	-6mm maxilla (duplicate)
28		+2mm mandible
30		-2mm maxilla
32		-6mm maxilla
34		+6mm mandible
36		0mm
38		-4mm maxilla
40		+4mm mandible
42	Caucasian male	+4mm mandible
44		+2mm mandible
46		-6mm maxilla
48		+6mm mandible
50		0mm
52		-6mm maxilla (duplicate)
54		-4mm maxilla
56		-2mm maxilla
58	Caucasian female	0mm
60		+2mm mandible
62		-2mm maxilla
64		-6mm maxilla (duplicate)
66		-6mm maxilla
68		+4mm mandible
70		+6mm mandible
72		-4mm maxilla

Appendix XIV: Example Psychomorph combination